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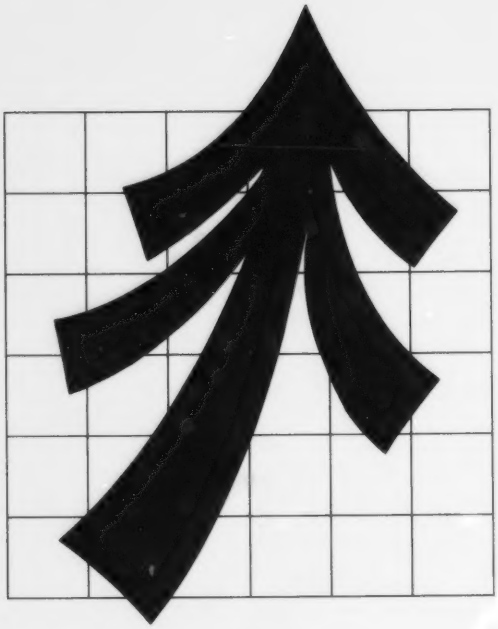

Forest Research in Canada: 1979/80 and 1985/86

I.C.M. Place

Forestry Research Advisory Council of Canada

Forest Research in Canada 1979/80 and 1985/86

Prepared by I.C.M. Place for the
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Executive Summary

Forests are the most prominent feature of the Canadian landscape. They stretch nearly 5000 km from Newfoundland to Vancouver Island and occupy 4.4 million km^2. Although nowadays some authorities tend to depreciate the importance of our forest resources, the economy is still highly dependent on the forest and, with the principal exception of the Prairie grain belt and the Montreal to Windsor corridor, virtually the entire country relies on the forest sector as a primary generator of employment and income.

The sector faces difficult times. Forest management is going through the awkward transition phase from harvesting wild forests to creating managed ones. Other materials are making serious inroads into the traditional uses of wood and growing trade barriers and competition from other countries are threatening Canada's position in international markets. The forest estate itself is under growing pressure for uses other than commercial forestry. The need for research was never greater.

In December 1979, the Canadian Forest Advisory Council published a report by Dr. O.M. Solandt entitled *Forest Research in Canada - 1979* (1) that summarized Canadian expenditures on research related to forestry by agency and broad subject matter. More up-to-date figures are needed to allow government and the private sector to make informed policy decisions on forestry research. The purpose of this report is to provide those figures and allow a comparison of expenditures in the fiscal year 1985/86 with those in 1979/80.

The report is the result of a rather superficial survey of expenditures for research and development related to forests and forest products, although the emphasis is on forestry rather than the products. Since the Canadian Forestry Service (CFS) is by far the largest forest research organization in Canada, its activity list has been used as the basis for the subject classification used in the report. It has, however, been subdivided into enough detail to allow comparisons with Solandt's data and it includes headings to cover topics not under research by the CFS.

The 1985/86 data in the report are fairly complete for the universities, the provincial forest services and the CFS. They are reasonable for federal agencies other than the Department of Regional Industrial Expansion, and are weak for relevant research by many provincial agencies such as fish and wildlife services. Although considerable information is available on industry research, actual expenditures often had to be estimated from the number of researchers involved. The data for research expenditures on solid wood products is weak except for the budget of Forintek. No information was collected on research by suppliers to the forest industry and the figures reported by Solandt in 1979 have merely been adjusted for inflation. Despite these short comings, the coverage of 1985/86 research expenditures is probably more complete than that reported for 1979/80. It is quite possible, however, that the report underestimates Canada's total research expenditures by as much as 5 percent.

Part I of the report records expenditures by agencies, such as government departments, industry, universities and so on. In Part II the same data are divided by subjects. There are some minor discrepancies between these two sets of data owing to the way in which the original returns were made and the difficulty of keeping track of the multiplicity of contract research. Table 37 (page 79) summarizes all the expenditures by agency and broad subject category.

In 1985/86, total research expenditures amounted to $219 million. This compares with expenditures reported by Solandt for 1979 of $196 million (in 1985 $) and by the Science Council of Canada for 1968 of $257 million (in 1985 $). Thus despite the fact that in the meantime the forest industry has expanded greatly in real terms and that pressures on the forest estate for uses other than industrial forestry have also grown, Canada is spending less on research related to forestry than it did in 1968.

If allowance is made for the total cost of research, Canada's expenditures in 1979/80 and 1985/86 were $245 and $289 million respectively in 1985 dollars (Table 37). In 1985/86, Canada's total research expenditures amounted 0.9% of the value of shipments, while industry's in-house spending on research was less than 0.1% of the same value and its spending on forestry as opposed to forest products was almost negligible. Total industry spending on research, including that of the industry suppliers and industrial research institutes and associations only amounted to 0.3% of the total value of shipments. Figures such as these make one question the wisdom of privatizing any more government research programs.

Largely owing to help from the CFS and Natural Sciences and Engineering Research Council, the university effort in research increased by about 300% between 1979 and 1985. For a variety of reasons, including the reluctance of both government and the forest industry to increase the size of their research staff, the universities may have difficulty in maintaining the current level of research. Among the provinces, both Alberta and Quebec have materially increased their research budgets, but even they have not added greatly to their staffs.

Operational spending by the CFS fell by $20.4 million annually (1985 dollars) during the six-year period between surveys; staffing decreased from 1068 person years to 873, and apparently the attrition continues.

The subject categories in Table 37 are rather broad to show meaningful trends in research and one should look at Tables 30 to 36 and Appendix 3 for detail. However, there has been a considerable increase in the efforts devoted to topics such as the environmental impact of forestry practices, acid rain, forest genetics, reforestation, and technology transfer. Relatively speaking, however, forest protection is being neglected, the Forest Insect and Disease Survey is suffering for lack of staff and money, and spending on forest products has just kept pace with inflation. Relatively few data are available for research on the non-consumptive uses of the forest, but such as there are suggest that important topics such as forest recreation are receiving little attention from the forest community.

In conclusion, there are many good individual forest research programs in Canada. In light of the forest sector's importance, however, the research picture as a whole is not a pretty one.

Acknowledgements

I wish to thank the Canadian Forestry Service for making its data freely available and those members of its Regional Forestry Centres who collected much of the information on provincial research expenditures. Thanks are also owing to many university, government and industry officials who made their time available to discuss forestry research in Canada.

Introduction

The most striking geographic feature of Canada is the mantle of forest extending from Newfoundland to Vancouver Island. Roughly 58% of the ten provinces is forest land. Although Canada is a forest country, Canadians are not a forest people. Most are city dwellers who fail to appreciate the vital contribution its forests make to employment, regional stability and the national balance of payments.

Many years ago Prof. A.R.M. Lower developed the thesis that the early exploitation of our forests generated the capital necessary to permit Canada to become an industrialized nation. It is fashionable in some circles nowadays to depreciate the importance of Canada's forest resources. But the economy is still highly dependent on the forest and with the two principal exceptions of the Prairie grain belt and the Montreal–Windsor corridor, virtually the entire country relies on the forest sector as a primary generator of employment and income. A few statistics will suffice.

From 1980 to 1984, primary forest production averaged 150 million m^3 of industrial wood annually. In 1984, direct employment in the forest industries was 270,000; salaries and wages were $7.4 billion; the value added was $13.2 billion; and the total value of shipments $32.8 billion. In 1985, export of forest products contributed a net $14.3 billion to Canada's balance of trade. This, however, is only part of the story. Estimating the full value of Canada's forest resources is difficult because so much of it is intangible. Forests moderate climate, clean the air, regulate streamflow and minimize floods, and provide the habitat for fish and wildlife that enrich outdoor experiences and support many of our native people.

Putting a dollar sign on this asset is well nigh impossible, but its value is obviously enormous and warrants a great effort in research to ensure that it is wisely managed. The need is particularly urgent now because Canada is going through the transition stage from harvesting wild forests to creating managed ones.

Purpose of the Report

In December 1979, Dr. O.M. Solandt submitted a report entitled *Forest Research in Canada - 1979* (1) to the Canadian Forestry Advisory Council, that summarized Canadian expenditures on research related to forestry by agency and broad subject matter. There has been no comparable survey since then and up-to-date figures are needed to enable government and the private sector to make informed policy decisions on forestry research. The purpose of this report is to provide those figures and allow a comparison of 1985/86 expenditures with those reportd by Solandt in 1979.

Definitions

In this report, the term research is used loosely to cover both research and development. Research implies scientific investigation carried out by means of experiment, survey or analysis to gain new scientific, technical, commercial, economic or social knowledge. Its essential characteristics are that the outcome of the work is uncertain, and that rigorous standards of evidence and proof are imposed. Results are often in the form of concepts. Development is the application of scientific knowledge to produce new or improved materials, devices, products, processes, systems or services. Experimentation is a dominant characteristic and is designed to provide the client with know-how.

Ideally, it would have been desirable to separate these two activities in the report. In practice, however, they tend to form a continuum and one man's research is often another man's development.

Preserving the distinction would have complicated data collection greatly and involved much more travel and face-to-face discussion than was possible.

Subject Classification

Since the Canadian Forestry Service (CFS) is by far the largest forest research organization in Canada, its activity list has been used as the basis for the subject classification used in this report. It has, however, been subdivided into enough detail to allow comparisons with Solandt's data and it includes headings to cover subjects not under research by the CFS.

The CFS activity listing is by objective rather than discipline. Although this does have some advantages, it does mean that research in the same discipline may appear under several different headings. Forest hydrology, for example, can appear under 'Environmental Factors and Forestry Practices' (e.g. watershed research on the Eastern Slopes of the Rocky Mountains) or under 'Environmental Impact of Atmospheric Pollutants' if the study is part of watershed research on the impact of acid rain. It depends on the objective of the research.

An outline of the main subject categories used appears below and Appendix I gives a more detailed breakdown.

Subject Categories

1. Forest environmental research
2. Forest production research
3. Forest protection research
4. Non-consumptive uses of the forest
5. Forest utilization research
6. Forestry services
7. Economics and forest policy research
8. Major capital

Procedure Followed

Data Collection

The primary objective was to get figures for operating and capital expenditures on research related to forestry for the fiscal year 1985/86. A secondary objective was to obtain an estimate of the professional and support person-years involved in forestry research. Reasonably complete data were available from some agencies, notably the Canadian Forestry Service (CFS), and these have been included. Much of the reporting was uneven, however, and no attempt has been made to estimate either the total number of person-years devoted to research or, except for the CFS, to separate minor capital and operating expenses.

Funds for the survey were limited and relatively little travel was possible. The CFS, however, made computer printouts of its program plans and research expenditures freely available, and requested its regional forestry centres to collect data on the research expenditures of provincial agencies.

Questionnaires went to 42 English and 17 French language universities or institutes, of which 43 responded. Questionnaires also went to 14 woodusing companies represented on the Research Committee of the CPPA Technical Section. Only three or four answered.

I visited the Forest Engineering Research Institute of Canada (FERIC) and the Pulp and Paper Research Institute of Canada (PAPRICAN) and had a long interview with the President of Forintek Canada Corp. I also visited the Woodlands Section of the Canadian Pulp and Paper Association, the Council of Forest Industries of British Columbia, the Ontario Forest Industries Association, and had discussions with numerous federal, provincial and industry officials. I made personal contact with most of the relevant federal agencies in Ottawa, as well as visiting several universities and talking with all of the deans of the university forestry schools.

Data Coverage

A serious difficulty in getting data is that many agencies not primarily concerned with forestry do not document their research expenditures related to forestry in a way that allows their easy identification or retrieval. Frequently they do not know what research they are conducting that is related to forestry. This is particularly true of university faculties other than those in forestry and federal agencies other than the CFS. A further difficulty is getting estimates of expenditures and staff involvement until long after the end of the fiscal year.

The data in this report are fairly complete for the universities, the provincial forest services and the CFS. It is reasonable for federal agencies, such as the Departments of Environment, Energy, Mines and Resources, Fisheries and Oceans, Agriculture and the National Research Council. Information is lacking, however, for research subventions by the Department of Regional Industrial Expansion and is weak for relevent research by many provincial agencies, such as departments of the environment, fish and wildlife services, provincial research councils, and so on.

Although considerable information is available on industry research, actual expenditures frequently had to be estimated from figures on the number of researchers involved. The data for research on solid wood products is weak except for the budget of Forintek. Much of it, however, is contract research for government agencies and these costs are included in the totals. No information was collected on research by the suppliers to the industry. I have assumed that their spending has remained unchanged since 1979, and the figures reported by Solandt have merely been adjusted for inflation. Finally, both federal and provincial agencies underwrite much of the research conducted by the universities and industry. Considerable effort has been made to avoid double counting of research expenditures, but without maintaining very close contact with the agencies concerned some double counting is inevitable.

Despite these shortcomings, the coverage of the 1985/86 expenditures is probably more complete than that reported by Solandt for 1979/80, particularly for government agencies and the universities. Nevertheless, I suspect it underestimates Canada's total expenditures by as much as 5%. A serious difficulty lies in deciding where research relating to forestry ends and one can be faced with an ever receding horizon.

Complete Costs

As in 1979, the reporting of costs has been very uneven. At one extreme, the industrial institutes report complete costs, including both direct costs and overhead. At the other extreme, the universities and some government departments tend to include only immediate operating expenses and often omit the salaries of the principal investigators.

To make the reports comparable, I have followed Solandt's procedure in adjusting expenditures as well as including the figures actually reported. With government agencies where administrative and research support expenses have been reported separately from direct program costs, these have been prorated where appropriate in some tables. To allow for complete overheads (e.g. fringe benefits, cost of all building maintenance and services, and for services such as accounting and senior management, etc.), government expenses have been increased by 50%. Since university figures lack not only those factors mentioned for government but usually also the direct salaries of the principal investigators, their costs have been doubled. Solandt assumed that industry and provincial research foundations reported complete costs and left their figures unchanged. This report does the same. I suspect, however, that some adjustments are generous. Some universities, for example, charge about 35% for overhead costs on contract research.

As considerable inflation has occurred in Canada since 1979, allowance for it has been made to permit fair comparison of expenditures. Since most of the expenditures discussed in the report were made by government, I have again followed Solandt's lead and used as deflator the implicit price index for government current expenditure on goods and services as reported by Statistics Canada. This index is based on 1971 as 100, and the relevant values for this report are:

1971 – 100
1979 – 230
1985 – 391 (estimated)

Report Structure

The report is divided into two main parts. Part I reports on the research expenditures by the different sectors; in part II the same data are subdivided according to subject.

Part I. Canadian Forest Research by Sector

The Provinces

Quebec, Ontario, Alberta and British Columbia have research units within their forest services and have substantial research programs. The other provinces do conduct research, but it tends to be applied R&D aimed at adapting existing technology to local conditions. For problems involving original research, they usually let contracts to university researchers, or rely on the federal government. In addition to the expenditures shown in the following tables, all provinces spent additional money under the federal/provincial forestry agreements, which are discussed later.

Newfoundland Department of Forest Resources and Lands

Table 1 shows the department's expenditures on research and development.

Table 1. Newfoundland Department of Forest Resources and Land Expenditures on Forest Research

Research activity	Expenditures $(000) 1979/80	1985/86
1. Forest environmental research	–	–
2. Forest production research		
(a) Tree seed and improvement	–	4
(b) Reforestation		96
(c) Tree and stand growth		2
Silviculture		125
Mensuration (growth & yield studies)		
Subtotal		**227**
6. Forestry services		
(b) Forest resource data (damage appraisal)		50
Total	**391**[a]	**277**

[a]Unspecified expenditures on silviculture, inventory, forest engineering and utilization.

Although the provincial research effort is not great, additional money is being spent under the federal/provincial forestry agreement and the total level of research in the province has probably increased since 1979.

PEI Department of Energy and Forestry

Table 2 shows P.E.I.'s expenditures on forestry research.

Table 2. PEI Department of Energy and Forestry Expenditures on Forestry Research

Research activity	Expenditures $(000) 1979/80	1985/86
1. Forest environmental research	–	–
2. Forest production research		
(a) Tree and seed improvement	–	205
(c) Tree and stand growth	–	91
	–	**296**
3. Forest protection	–	–
4. Non-consumptive uses of forest	–	–
5. Forest utilization		
(a) Energy from the forest	–	45
(b) Forest engineering	–	83
	–	**128**
6. Forestry services		
(b) Forest resource data	–	66
Total	–	**490**

In 1979/80, the province had no research program. Now it is putting a relatively great effort into tree and seed improvement in line with its general objective of improving the quality of the island's forests. Three professional and 16 support personyears are involved in this program.

Nova Scotia Department of Lands and Forests

Table 3. Nova Scotia Department of Lands and Forest Expenditures in Forest Research

Research activity	Expenditures $(000) 1979/80	1985/86
1. Forest environmental research	..	–
2. Forest production research	..	
(a) Tree and seed improvement		402
(b) Reforestation		166
(c) Tree and stand growth		154
(d) Management systems		65
Total		**787**
3. Protection	..	
(c) Chemical pesticides research Herbicides		96
4. Non-consumptive uses of forest	..	150
	500[a]	**1 033**

[a]Research of an operational nature in silviculture, mensuration, land classification, tree improvement, reforestation, remote sensing and forest management.

Nova Scotia's research program reflects the nature of its operational program, with the emphasis being largely on tree improvement, reforestation, and tree and stand growth (see Table 3). It involves about 6 professional and 21 support person-years. Even allowing for inflation, research expenditures have increased considerably since 1979/80.

New Brunswick Department of Natural Resources and Energy

As Table 4 shows, New Brunswick's spending on research has increased since 1979/80 but the increase after allowing for inflation was not great. The work is mostly applied research in direct support of the province's operational program and reflects the continuing concern with forest productivity. About 17 professional and 11 support person- years are involved in the program. In addition to the expenditures shown in Table 4, the province supplies about $245k for contract research (largely on spruce budworm) at the University of New Brunswick.

Table 4. New Brunswick Department of Natural Resources and Energy Expenditures on Forestry Research

Research activity	Expenditures $(000) 1979/80	1985/86
1. Forest environmental research		
(a) Environmental factors	10	129
(b) Impact of atmospheric pollutants	–	110
(c) Forest and plant ecology	–	254
(site classification)	–	
	10	**493**
2. Forest production research		
(a) Tree and seed improvement	150	4
(b) Reforestation	50	73
(c) Tree and stand growth	30	69
(d) Management systems	75	154
	305	**300**
3. Forest protection		
(a) Fire	11	–
(b) Pest biology	51	4
(c) Pesticide research		
Budworm	87	–
Herbicides	140	120
	289	124
4. Non-consumptive uses of forest	–	195
5. Forest utilization (forest engineering)	–	8
6. Technology transfer	–	20
Total	**604**	**1 140**

Quebec Department of Energy and Resources

The Ministry provides an exceptionally well organized and detailed breakdown of its research program annually. Unfortunately for the purposes of this report, the format used by MER has varied somewhat from year to year and only the 1986/87 budget figures lend themselves to reordering into the subject classification used here. To allow comparison with Solandt's data for 1979/80, Table 5 follows MER's subject classification.

Table 5. Quebec, Department of Energy and Resources (MER) Expenditures on Forestry Research

Activity	Expenditures[a] $(000)			
	1979/80	1984/85	1985/86	1986/87
Knowledge of the forest (ecology, yield & inventory)	596	620	691	508
Forest improvement (tree breeding, seed and planting stock, reforestation, stand treatment)	1 281	3 907	6 294	6 759
Forest protection (insects & diseases)	67	1 400	1 460	1 617
Forest management	161	70	50	102
Forest products - total	102	905	546	708
(solid wood products)		(457)	(272)	(658)
(pulp & paper)		(195)	(223)	(50)
(other products)		(253)	(51)	–
Technology transfer	138	200	284	948
Scientific & technical services (research support)	..	..	591	773
Administrative services	..	986	1 000	1 081
Total	**2 345**	**8 088**	**10 916**	**12 496**
Subventions[a]	–	1 638	1 975	2 083
Contracts[a]		1 402	1 370	1 150
Person-years				
permanent & contract	..	71.6	74.6	74
seasonal	..	..	..	185.5

[a]Expenditures on contracts and subventions are included in the totals shown for MER's budget.

MER's expenditures on forestry research have more than kept pace with inflation since 1979/80. Since 1984/85, it has been spending more than $3 million annually on contract research and for subventions to universities. In forest protection, MER does not conduct any research on forest fire control, but in 1986/87 did contribute $580K to the Maniwaki Technology Transfer Centre for the transfer of fire management technology into practice. Most of its research in protection is for control of spruce budworm, but it is devoting considerable research effort to the problem of sugar maple deterioration.

Ontario Ministry of Natural Resources (OMNR)

Table 6 shows OMNR's expenditures on research related to forestry. Those given for 1986/87 consist only of the budget for the Ontario Tree Improvement and Forest Biomass Institute, which has an establishment of 31.5 professional and 53.3 support person-years.

Unfortunately this picture of OMNR's research is incomplete because it does not include relevant expenditures by the Fisheries and Wildlife Branches. Two more Technology Development Units have been opened whose budgets are not included here.

OMNR's spending on research *per se* has clearly not kept pace with inflation. It is, however, devoting much more money to technology development and transfer than previously. According to a report prepared for the Ontario Forestry Council (2), approximately $16 million is spent annually in Ontario for forestry R&D done by the federal and provincial governments, universities and industry. On research *per se*, $9.1 million was spent in 1984/85 and $9.9 million in 1985/86.

In addition to OMNR, the Ministry of the Environment funded the following research on the forest environment:

	$(000)
Impact of atmosphere pollutants (acid rain)	391
Biogeochemistry	335
	726

Table 6. Ontario Ministry of Natural Resources Expenditures on Forestry Research

Research activity	Expenditures $(000) 1979/80	1985/86	1986/87
1. Forest environmental research	–	50	–
2. Forest production research			
(a) Tree seed and improvement	677	865	747
(b) Reforestation	616	713	913
(c) Tree and stand growth	898	768	768
	2 191	**2 396**[a]	**2 428**[a]
3. Forest protection			
(a) Fire	–	276	–
(b) Pest biology	450	93	..
(c) Herbicides and pesticides	–	187	–
(d) Integrated pest management	–	26	–
	450	**582**[b]	–
5. Forest utilization research			
(a) Energy from the forest	–	46	..
(b) Forest engineering	566	–	..
	566	**46**	..
6. Forestry services			
(c) Technology transfer	–	3 376[c]	101
(d) Subventions & special contracts		346[d]	..
Subtotal	–	**3 722**[b]	**101**
Program management & support[e]	–	638	495
Total	**3 207**	**7 384**	**3 024**

[a]Includes $280K COFRDA funds for 1985/86 and $608k for 1986/87.
[b]Primarily development activities.
[c]Includes $3283K for Technology Development Units at Timmins and Brockville.
[d]University funding (including ORRRGF).
[e]These support expenditures are included in the program items for 1979/80.

Manitoba Department of Natural Resources (MDNR)

Manitoba has no forest research unit as such, but the service does conduct some applied research in direct support of its operational program. The Manitoba Departments of Environment and Industry also do some research on the impact of smelter fumes. These expenditures are summarized in Table 7, but the province's chief research expenditures in forestry are covered under the Federal/Provincial Forestry Development Agreements.

Table 7. Manitoba Provincial Expenditures on Forestry Research

Activity	Expenditures[a] $(000) 1979/80	1985/86
1. Forest environmental research		
(b) Impact of atmospheric pollutants	80	160
2. Forest production	130	
(a) Tree seed and improvement		224
3. Forest protection	–	
(d) Integrated pest management		105
	210	489

[a]Five professional and two support person years are involved.

Saskatchewan Department of Parks and Renewable Resources

Table 8 summarizes the department's expenditures on forestry research other than those funded by the Federal/Provincial Forestry Development Agreement, which are covered elsewhere.

Table 8. Saskatchewan Forest Service Expenditures on Forestry Research

Activity	Expenditures $(000) 1979/80	1985/86
2. Forest production research	–	
(a) Tree seed and improvement	–	10
(b) Reforestation	–	24
(c) Tree and stand growth	–	48
(d) Management systems	–	30
	–	112
3. Forest protection	–	
(a) Forest fire research	–	14
6. Forest services	–	
(a) Forest insect and disease survey (Dutch elm disease)		62
(b) Grants and special contracts		6
Total	–	194

About 1.7 professional and 2.3 support person-years are involved.

Alberta Department of Forestry, Lands and Wildlife

The Alberta Forest Service has a substantial research program of its own as well as a program under the Federal/Provincial Forestry Agreement. To a considerable extent, it conducts its program via contracts with the universities and industry.

Table 9. Alberta Forest Service (A-base) Expenditures on Forestry Research

Activity	Expenditures[a] $(000) 1979/80	1985/86
1. Forest environmental research	–	
(a) Environmental factors	130	
(c) Environmental impact of devel	100	101
(d) Forest and plant ecology	52	100
	282	**201**
2. Forest production research		
(a) Tree seed and improvement	82	470
(b) Reforestation	50	362
(c) Tree and stand growth		100
	132	**932**
5. Forest utilization research	..	
(b) Solid wood products		(800)[b]
6. Forestry services		
(d) Grants and contributions	..	603[c]
	414	**1 736**

[a] 16.0 professional + 1.3 support person-years
[b] Contribution to Alberta Research Council (ARC)
[c] $100K grant to Forintek, $136K contracts to industry and $367K contracts to universities.

British Columbia Ministry of Forests and Lands

Table 10 summarizes the forest research expenditures of the provincial ministry.

Table 10. BC Ministry of Forests and Lands Expenditures[a] on Forestry Research

Activity	Expenditures[a] $(000) 1979/80	1985/86
1. Forest environmental research		
(a) Environment and forestry practices	–	140
(b) Ecology and soils	2 100	1 512
Tree physiology	292	299
	2 392	1 951
2. Forest production research		
(a) Tree seed and improvement	1 908	3 375[b]
(b) Reforestation		
Nurseries and seed	924	
Plantation establishment	1 048[c]	1 024
(c) Tree and stand growth		
Growth and yield	322	
Biometrics	132	
	2 278	5 645
3. Forest protection	–	
(b) Insects	24	
4. Non-consumptive uses of forest	–	
Fisheries and hydrology		631
Wildlife		783
Range management		178
		1 592
5. Utilization of the forest		
(b) Solid wood products[d]	(1 450)[d]	(1 450)[d]
6. Forestry services		
(c) Grants and special contracts (universities)		(377)
Total	5 480	9 212

[a]Most 1985/86 data are from 5th Ann. Rep. BC For. Res. Council (3).
[b]Includes O&M for Cowichan, Kalamalka and Red Rock field stations.
[c]Lumped in Solandt's report.
[d]Contribution to Forintek.

Comparison of the 1979/80 and 1985/86 data is not really valid because Solandt's coverage was not as comprehensive. In 1984/85, the total budget was approximately $9922K of which $7271K was in-house research, $1450K a contribution to Forintek, $171K university research and $1080K other.

The tabulation below suggests that the staff numbers of the Research Branch have been falling.

Year	Continuing staff Person-years		
	Professional	Support	Total
1983/84	117	76	193
1984/85	70	107	177
1985/86	69	102	171

The relative numbers of professional and support staff for 1983/84 may be in error because they were assumed from the title of the position. No published information is available on seasonal staff, but informal communication suggests that their numbers have been drastically reduced.

According to the Forest Research Council of British Columbia (3), total research expenditures by all agencies in British Columbia were approximately $50 million in 1985/86. However, much of this was development work, including a major sum for bringing a new product to market.

Summary of Provincial Forest Service Expenditures

Table 11 shows the A-base research expenditures of the provincial forest services less money for contributions, subventions and contract research shown elsewhere. Ostensibly, spending by the provincial forest services has more than doubled since 1979; but if allowance is made for inflation, the 1985/86 expenditures represent an increase of only about $6.3 million over the 1979 figures. Even this, however, is probably an overestimate because the 1985/86 survey was more inclusive than that in 1979/80; the British Columbia total, for example, includes $1.6 million for research on fish and wildlife habitat related to forestry and for rangeland management, subject areas not looked at in 1979.

Real expenditures on research have increased materially in Quebec and Alberta, and decreased in Ontario and British Columbia during the past six years. On the other hand, Ontario has greatly increased its spending on technology transfer. It is also true that some of the provincial services, notably British Columbia, are spending considerable money on research through the federal/provincial forestry agreements. Much of this work, however, is of a developmental nature and some comparable work was in progress in 1979 under federal/provincial general development agreements.

Table 11. Forest Research Expenditures by the Provincial Forest Services[a]

Province	Expenditures $(000)		
	1979/80	1979/80 (in 1985 dollars)	1985/86
Newfoundland	391	665	277
Prince Edward Island	–	–	490
Nova Scotia	500	850	1 033
New Brunswick	604	1 026	1 140
Quebec	2 345	3 987	7 571
Ontario	3 207	5 452	7 020
Manitoba	210	357	498
Saskatchewan	–	–	194
Alberta	414	704	1 260
British Columbia	5 480	9 316	9 212[b]
Total	**13 151**	**22 357**	**28 695**

[a]Does not include contributions to Forintek, etc. subventions to universities and contract research shown elsewhere.
[b]Includes $1592K in expenditures on fisheries and wildlife habitat related to forestry and on rangeland research, which were not covered in the 1979/80 survey.

Provincial Research Agencies

Most provinces have a provincial research agency of some sort. Unfortunately a detailed outline of their research expenditures related to forestry is only available for the Science Council of British Columbia (BC Research). The research related to forestry that is conducted by these agencies is usually being performed for industry in their own province, often with industry money. However, they receive funding from provincial, federal and industry sources.

Science Council of British Columbia

Table 12. Expenditures on Forestry Research

Research activity	Expenditures $(000) 1979/80	1985/86
1. Forest environmental research	..	–
2. Forest production research		
(a) Tree and seed improvement		576
(b) Reforestation (nurseries)		167
(c) Stand tending		50
Growth & yield		21
3. Forest protection	..	
(b) Insects		76
4. Non-consumptive uses of forest	..	
(a) Wildlife		76
5. Forest utilization research	..	
(b) Solid wood products		289
(c) Pulp and paper		111
(d) Forest engineering		147
Total	**718**	**1 513**

In 1979, almost half the 25 forest related research projects were devoted to chemical problems in paper mills or mill effluent problems. Others were related to sawmill problems and the use of wood waste, and six projects were in the area of industrial health.

Dollar expenditures have doubled since 1979/80, but the real increase only amounts to about 26%. Although the Science Council may have increased its actual expenditures in forest utilization, most of the increase has occurred in the area of forest production research.

Centre de recherche industrielle du Québec (CRIQ)

In 1985/86, CRIQ conducted many internal research projects and spent $4.5 million on forest sector research (see Table 13). By 1985/86, its role had changed and it now does mostly research at industry's request. Its expenditures for forest and forest products research were approximately $1.7 million of which 60% were devoted to solid wood products research and the remainder to biotechnology and logging machines.

Table 13. CRIQ's Expenditures on Forestry Research

Research activity	Expenditures $(000)	
	1979/80	1985/86
Forest production	1 012	340[a]
Forest protection	73	–
Forest utilization		–
Solid wood products	2 628	1 020
Pulp and paper	65	340
Forest engineering	775	
Total	**4 553**	**1 700**

[a]Biotechnology

Fonds F.C.A.R.

The *Fonds pour la formation de chercheurs et l'aide à la recherche* (FCAR) was created on November 28, 1984, under an act encouraging scientific and technological development in Quebec.

The duties assigned to the organization by the Act are to promote or to assist research financially in post-secondary institutions; work by researchers not affiliated with these institutions; dissemination of knowledge in all areas of research; and training researchers through scholarships. These funds are granted to graduate students, post- doctorate researchers, individuals wishing to re-enter the channels of research or to upgrade themselves in specific areas.

For 1985-86, the Fonds had a budget of $29.6 million to fund research in Quebec of which approximately $300,000 was used to fund forest and forest products research. Since its research support is included in the university expenditures, it will not be taken into account here.

Ontario Research Foundation (ORF)

In 1979, the Ontario Research Foundation had a budget of $400K related to forestry and forest products. Its 14 projects dealt with the use of forest biomass and waste paper, problems of the pulp and paper industry, and several projects on forest management.

Its budgets for 1984 and 1985 are shown below in $(000).

	1984	1985
Solid wood products	50	100
Pulp and paper	250	250
	300	**350**

These suggest that ORF's expenditures on forestry have diminished materially if inflation is taken into account.

Other Provincial Research Agencies

The Alberta Research Council received a grant of $800K from the Alberta Forest Service for research on solid wood products.

The NB Research and Productivity Council conducted a project on tracing aerially applied Bt, which had a budget of $49,427 ($10,000 from CFS and 39,427 from DSS).

The Nova Scotia Research Foundation had a budget of $60,000 ($28,668 from CFS) to develop an ectomycorrhizal inoculum for nursery conifers. Undoubtedly the provincial research agencies conducted more forestry research than is reported here.

Federal Government Agencies

Many federal agencies either conduct and/or fund research in the forestry sector. The chief among these is the Canadian Forestry Service (CFS), which is discussed at length later. The following sections outline the expenditures of other federal agencies.

National Research Council (NRC)

NRC has underwritten considerable research related to forestry through its programs on bioenergy and technology transfer to industry. It also conducts some forestry research itself at the Plant Biotechnology Institute at the University of Saskatchewan (Saskatoon).

Although the term bioenergy is relatively new, man has been exploiting the energy content of wood, animal manure and crops such as straw for thousands of years, mainly through direct combustion. Forest biomass contains three basic components: cellulose, hemicellulose and lignin.

NRC's program on bioenergy fells into two main categories: biomass production (growing, inventory and harvesting) and conversion of biomass into fuels or energy. In production research, NRC has funded development of harvesting machines and techniques for short-rotation plantations of poplar. In conversion, it has underwritten research on wood gasification, anaerobic digestion of animal manures and mill waste to biogas, and fractionation of wood into its lignin, hemicellulose and cellulose components.

Between 1980/81 and 1984/85, NRC's Division of Energy spent about $7.7 million on bioenergy. Unfortunately, this program has been a casualty of budget cuts and was phased out in 1985/86. Approximate expenditures for that year are shown below.

Table 14. NRC's Expenditures on Forest Biomass Research

Activity		Expenditures $(000)	Contractor
Production		99	Universities
		455	Industry
	Sub-total	**554**	
Conversion		374	Universities
		139	ORF & CRIQ
		110	Forintek
		122	Industry
	Sub-total	**745**	
	Grand total	**1 299**	

Of this total of $1299K, $722K was contracted to universities, provincial research foundations and Forintek, and is reported under those headings. Most of the remaining $577K was contracted to specialty engineering firms. A portion of the cancelled NRC program on biomass conversion has been taken over by the Department of Energy Mines and Resources.

NRC underwrites considerable research in the forestry sector through its programs in technology transfer, principally PILP (Program for Industrial Laboratory Projects) and IRAP (Industrial Research Assistance Program). Expenditures for 1985/86 are given below.

Table 15. NRC Forestry Expenditures under PILP and IRAP (1985/86)

Research Activity	PILP	IRAP	Total
2. (a) Biotechnology	409	–	409
(b) Reforestation[a]	291[a]	291	
5. (b) Solid wood products	71	71	
Pulp and paper			
(c) Machinery	76	260	336
Processing	180	169	349
(d) Forest engineering	29	–	29
Chemicals	–	300	300
	694	**1 091**	**1 785**

[a]Mostly plantation research

As indicated above, NRC also conducts research in the biotechnology of conifers and semiochemistry at the Plant Biotechnology Institute in Saskatoon. The objectives of the conifer research are to: (1) translate cell and molecular technologies developed for angiosperms to gymnosperms; (2) develop techniques for cloning elite conifer specimens; and (3) develop DNA recombinant techniques for genetic engineering of conifers. The semiochemistry research is aimed at: (1) discovery and identification of insect pheromones, and (2) developing protocols for monitoring insect populations using sex attractant lures. The resources devoted to this research are given below.

Activity	Expenditures $(000)	Person-years	
		Prof.	Support
Conifer biotechnology	380	3	3
Semiochemicals	200	2	2
	580	**5**	**5**

Of this $580, the Natural Sciences and Engineering Research Council (NSERC) contributed $60K and NRC most of the remainder. Since much of the other research at the Institute impinges on forestry, the above figures are a conservative estimate of relevant expenditures.

Finally, the tabulation below summarizes NRC's 1985/86 expenditures on research related to forestry that are not reported under other headings.

Activity		Expenditures $(000)
Industrial assistance		
PILP		694
IRAP		1 091
	Subtotal	**1 785**
Biotechnology		580
Bioenergy		577
	Total	**2 942**

Natural Sciences and Engineering Research Council (NSERC)

NSERC is the chief source of federal funding for university research in general. Its aid takes a wide variety of forms, including individual operating grants, strategic and general development grants, equipment grants, scholarships, fellowships, postdoctoral fellowships, funding of chairs in specific disciplines, and so on. Together with the CFS, it has been by far the largest source of money for forestry research in Canadian universities. During the 1986/87 fiscal year NSERC took over responsibility for much of the CFS Human Resources Program, including the block grants to the forestry schools. Since its research support is included in the university expenditures, it will not be listed separately here.

Environment Canada

Nearly every service within Environment Canada conducts some research related to forestry. These efforts are outlined briefly below.

Atmospheric Environment Service (AES)

AES plays a major role in the Long Range Transport of Air Pollutants Program (LRTAP) which deals with acid rain. Resources devoted to that portion of LRTAP bearing most directly on forestry are outlined below for 1985/86.

Research activity	Expenditures $(000)	Person-years (Prof.)
Canadian air & precipitation network	354	3
Dry deposition on forests	158	4
Chemistry of high elevation fog (contract)	192	0.5
Oxident chemistry study	168	4
	872	11.5

Although some activity of this sort was in progress in 1979, no research expenditures were listed in the Solandt report.

Canadian Wildlife Service (CWS)

Several years ago, the Canadian Wildlife Service had a considerable research program on the effects of forestry practices on wildlife populations and habitats. Owing to staff reductions in 1984/85, CWS now has only four relevant studies in progress. Three of these deal with the ecology of birds in forest habitats and one with the effects of forest spraying for spruce budworm control on bird populations in New Brunswick. Resources devoted to these studies in 1985/86 were $76K and 5 professional and 0.5 support person-years.

Inland Water Directorate (IWD)

In 1985/86, IWD spent $40K on the Marmot Creek watershed studies. This is a cooperative project with the CFS and Alberta Forest Service aimed at evaluating the effect of vegetation management in the eastern slopes of the Rocky Mountains on the water regime of forested watersheds. During the 60s and 70s, IWD devoted a large effort to such watershed research, but this research has either been completed or superceded by studies of higher priority.

In addition to Marmot Creek, IWD spent $20K on analytical services for acid rain studies in forest areas.

Parks Canada

Much of the National Parks system consists of forest land, and Parks Canada has devoted much study to their ecology and biophysical classification. Initially, this entailed considerable research, most of which was performed at Parks Canada's expense by the CFS. The research element, however, has declined and in 1985/86 relevant expenditures had dwindled to about $12K and these were devoted to fire control. Expenditures in 1979/80 were $250K.

Environmental Protection Service (EPS)

EPS undoubtedly helps fund and collaborates in considerable R&D of direct or indirect importance to the forest sector on pollution abatement in wood processing plants and on the impact of pesticides and herbicides. In 1984/85, for example, its R&D program on water pollution control

technology involved 18 person-years and $925K of departmental money and $2024K of external money. Unfortunately EPS' accounting system does not allow any easy identification of how much of this effort related to the forest products industry and the time available for this survey precluded a detailed examination of EPS' program. An informal 'guesstimate' of 1985/86 expenditures for R&D on pulpmill pollution abatement was $80K for internal and $600-800K for external funding.

EPS conducts some research in the regions on the impact of pesticides used in forestry. No one in Ottawa, however, seemed to know what work was in progress and the only response from the regions indicated an expenditure of $42K in the Altantic Region on chemical pesticides.

Department of Energy, Mines and Resources (EMR)

Canada Centre for Remote Sensing (CCRS)

The total budget of CCRS is about $19 million, all of which is devoted to R&D. It has no specific budget allocation for forestry as such, but does have one professional who deals only with forestry matters. In 1985/86, it spent roughly $130K on specifically forestry applications. It is currently working with the forest inventory groups of the New Brunswick and British Columbia Forest Services. It is also working closely with the Petawawa National Forestry Institute on the use of optical scanners. As in 1979, about 10% of the users of CCRS' output are in forestry, hence a figure of $1.9 million is probably a reasonable estimate of its effort in forestry R&D. This compares with an expenditure of $0.9 million in 1979/80 ($1.53 million in 1985 dollars).

Bioenergy Development Program

Under the Bioenery Development Program, EMR indicates the following expenditures:

1985/86	1986/87	1987/88
	$(000)	
5 500	7 500	6 500

Of the 1985/86 expenditures, $3.2 million (and probably more) were clearly devoted to R&D on wood and mill residue gasification and liquefaction, testing of wood-burning stoves and furnaces, and so on in the general area of forest biomass utilization. Of this total, however, $370K was contracted to Forintek, $730K to provincial research agencies (BCR, ORF & CRIQ) and $640K to universities and is thus reported under those headings (not necessarily under biomass). The remaining $1.7 million was contracted to industry, mostly specialty engineering firms.

Total EMR expenditures in 1985/86 on R&D related to forestry but not reported elsewhere are thus:

	$(000)
Remote sensing	1 900
Biomass conversion	1 700
	3 600

This compares to an expenditure in 1979 of approximately $2,380K (in 1985 dollars).

Department of Fisheries and Oceans (DFO)

In the past, the Department of Fisheries and Oceans has conducted considerable research on the effect of forestry practices, such as use of pesticides and logging on fish populations and habitat. Indeed, the Forest Research Council of British Columbia reports DFO research expenditures on fisheries and hydrology related to forestry of $600K in 1985/86 in British Columbia alone. However, the DFO Fisheries and Biological Science Directorate reports only the following relevant expenditures for the whole of Canada for the same year (specifically in B.C., Manitoba and the Atlantic Provinces).

Table 16. DFO Research Expenditures Related to Forestry

Activity	$(000)	Person-years
1. Environmental factors		
(a) Impact of forestry practices	98	6
(b) Impact of aerial pollutants	145	4
3. Forest protection		
(c) Pesticides and herbicides	30	3
Total	**273**	**13**

This latter estimate is probably the more accurate. Big projects, such as the study of the effects of logging at Carnation Creek on Vancouver Island, are nearing conclusion.

The Oceanographic Sciences Directorate of DFO has also spent money on developing the Fluorescence Line Imager (FLI) to monitor ocean primary productivity. The FLI, however, is now on loan to Moniteq Ltd., which has successfully demonstrated the instrument's capability to monitor stress symptoms in forests suspected of being damaged by acid rain.

Agriculture Canada (CDA)

This section deals only with the relevant research conducted by the Research Branch of Agriculture Canada.

Biosystematic Research Institute (BRI)

The most important direct contributions of Agriculture Canada to forestry research are the taxonomic services in entomology and mycology of the Biosystematics Research Institute. The CFS seconds two professionals and one technician to BRI who work exclusively on forestry problems. However, about 30% of the effort of the other 53 professionals and 68 support staff is devoted to forestry-related problems. This translates to a contribution of about $1.45 million in operating expenses and $120K in capital from BRI's budget to forestry research.

(BRI also devotes about 40% of its resources to national problems in health and welfare, environmental assessment and protection, parks, wildlife, recreation, forensics, law and defence. It is thus a very useful and important organization within the federal government. Since, however, only about 30% of its resources are devoted to CDA's own program, it has difficulty in protecting its establishment and budget from continued attrition.)

Other CDA Research

Canada Agriculture also devotes about two professional plus supporting staff person- years to research on maple sugar production - say $300K annually. It continues research on selection, culture and protection of shade and ornamental trees at its Assomption (Quebec) and Morden (Manitoba) Research Stations. This effort involves three professional and three support staff person-years, an expenditure of about $450 annually.

These expenditures are only the most obvious of CDA's contributions to forestry research. The Research Branch has a large and varied program on fruit and nut trees, plant physiology and genetics, entomology and pathology, soils, pesticides and so on. Although not aimed at forestry, much of this research has implications for it.

The Inventory of Canadian Agricultural Research also shows that considerable research on shade and fruit trees and woody plants is being conducted by provincial departments of agriculture and at schools of agriculture across Canada.

CDA's direct expenditures on research related to forestry are summarized below.

Activity	Expenditures $(000)		Staff (Person-years)	
	1979/80	1985/86	Prof.	Supp.
2. Forest production				
(a) Tree breeding	250	750	5	5
3. Forest protection				
(b) Insects & diseases	650	1 570	16	20
Total	**900**	**2 320**	**21**	**25**

Canadian Forestry Service (CFS)

One of the anomalies of the Canadian federal system is that although the provincial governments own and are responsible for management of most of the forest resources within their boundaries, the federal government plays the dominant role in forestry research and development and in many strategic and international aspects of the forest sector. The most important agency in discharging the federal responsibility for forestry is the Canadian Forestry Service. The CFS has led a chequered existence and at one time or another has been part of at least ten different federal departments. At present it is part of the Department of Agriculture, but reports to the Minister of State for Forestry.

Since 1981, the CFS has been responsible for the administration of the Federal/Provincial Forestry Development Agreements and since 1984 has been designated the lead agency for forestry in the federal government. This has led to greatly increased responsibilities and a more complex organization. Figure 1, however, shows the present organization of those parts of the CFS responsible for conducting research. The six regional forestry centres (until recently forest research centres) report directly to the Assistant Deputy Minister, Operations, of the CFS, but receive functional quidance for their research programs from the Director-General, Research and Technical Services (now the Forest Science Directorate) in Ottawa. The two national forestry institutes report directly to the Assistant deputy Minister (Policy).

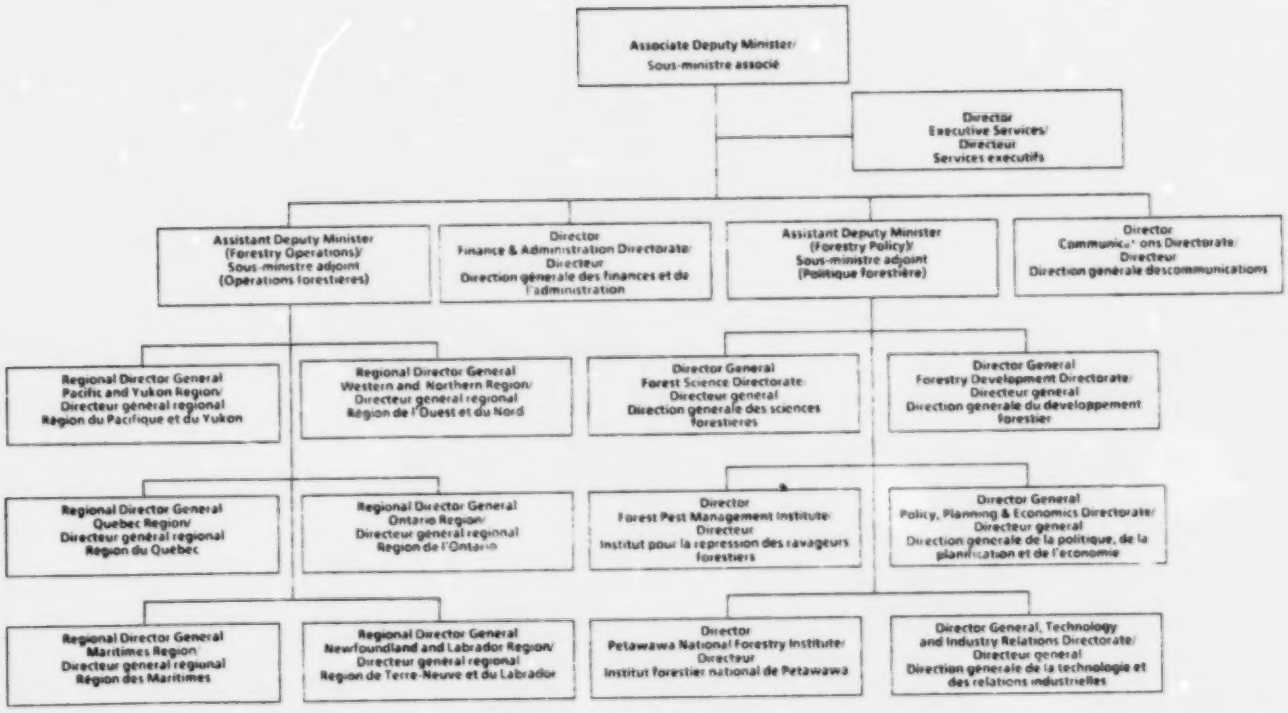

Figure 1. Organization of the Research Services of the Canadian Forestry Service

All six forestry centres conduct a regional research program and forest and insect survey, help plan and administer shared-cost federal/provincial forestry agreements, and provide economic analysis of regional opportunities. They all help run and administer portions of the national program on biomass production (ENFOR). There is an applied research component in each of the federal/provincial agreements for which they are responsible. The nature of regional forestry problems, however, greatly affect the research emphasis of their programs. Table 17 shows the distribution of the CFS operational resources in research, exclusive of the agreements programs. A few comments follow on each establishment.

(1) **Newfoundland Forestry Centre** (St. John's)

The Newfoundland Forestry Centres program reflects the fact that it is practically the sole forest research agency in the province. Emphasis is given to research on reforestation and tree and stand growth of black spruce and balsam fir, and to insect and disease control. Spruce budworm, hemlock looper and balsam woolly aphid are all serious current or potential threats to the forest. The Centre has also developed unique expertise on peat and wetlands.

(2) **Maritimes Forestry Centre** (Fredericton, N.B.)

The Maritimes Forestry Centre is responsible for federal research in New Brunswick, Nova Scotia and Prince Edward Island. Two overriding problems are the need for control of spruce budworm and to increase forest productivity to meet the wood needs of the existing industry. Much of the Centre's research effort is devoted to these problems, including its strong program on tree improvement. It also plays an important role in the national acid rain project (LRTAP) and has developed expertise in the production and marketing of Christmas trees.

(3) **Laurentian Forestry Centre** (Quebec City)

The Laurentian Forestry Centre Program emphasizes research on forest production and insect and disease control, especially biological control methods for spruce budworm. It has a strong program in tree improvement for spruce and jack pine, and participates in the national acid rain project (LRTAP).

(4) **Great Lakes Forestry Centre** (Sault Ste. Marie)

The Great Lakes Forestry Centre is one of the two largest centres and has strong programs on reforestation, the silviculture of black spruce, insect and disease control, and fire research. It has a significant program on acid rain and is the only CFS centre working on the biological impact of the mechanization of silviculture.

(5) **Northern Forestry Centre** (Edmonton)

The Northern Forestry Centre is responsible for federal research in the three Prairie Provinces and the Northwest Territories. It has strong programs on the environmental impact of toxic substances, regeneration and plantation management, stand productivity, nursery management, and wetlands research. Its research in forest hydrology is winding down.

(6) **Pacific Forestry Centre** (Victoria)

The Pacific Forestry Centre is responsible for British Columbia and the Yukon Territory. It is the largest of the regional forestry centres. Although its program is broad, the stress is on tree growth and silvicultural systems, and protection against insects and diseases.

(7) **Forest Pest Management Institute** (Sault Ste. Marie)

The Forest Pest Management Institute works mostly on developing environmentally acceptable control strategies for forest pests. The strategies involve identifying safer pesticides, techniques for

delivering these to target pests, monitoring their persistence in the environment and their effects in non-target organisms. Much of the research deals with highly selective microorganisms and biological materials that affect adversely the growth, development, mating success and survival of target pests. The Centre also conducts research on herbicides.

(8) **Petawawa National Forestry Institute** (Chalk River)

The Petawawa National Forestry Research Institute was formed in 1979 by amalgamation of three former CFS establishments: the Forest Management and Forest Fire Research Institutes from Ottawa and the Petawawa Forest Experiment Station. It has strong programs in tree genetics and biotechnology; fire behaviour, management and ecology; forest management modelling; and forest inventory and data systems. It houses the National Tree Seed Centre, and has about half the data handling and computer capacity of the CFS.

As Table 17 shows, the CFS operational resources for research in 1985/86 were 877 person-years and roughly $45 million dollars. These figures compare with 1063 person- years and $30 million in 1979/80. In 1985 dollars, the 1979/80 budget would amount to $51 million. Not all of the people and money that Solandt's figures show actually supported research, but most of them did and operational funding and staff support for the CFS research program has obviously declined materially. Moreover, about $3.2 million of the $13.2 million for operations and maintenance in the 1985/86 budget were spent on contracts of one sort or another.

Table 17 also shows the funds for grants and contributions administered by CFS headquarters. In 1985/86, these amounted to $12.3 million compared with $10.2 million in 1979/80. In 1985 dollars, the latter figure would be roughly $17.3 million. Thus support for the operational budget of the CFS declined by about $11 million in 1985 dollars during the 6-year period.

Operating resources, however, are not the whole story. As Table 18 shows, minor capital for 1985/86 amounted $12.8 million for equipment and $1.6 million for maintenance although a cut during the fiscal year reduced this budget by $1.6 million. It is not clear whether Solandt's figures include minor capital. Much of this money for minor capital is part of a special program to allow the field establishments to modernize equipment. They received roughly $9 million in 1985 and $7 million in 1986 and 1987 for this purpose, but these funds will not become part of the continuing A-base budget.

Table 17. Canadian Forestry Service Operational Resources in Research 1979/80 and 1985/86

Establishments	1979/80			1985/86		
	Person-years		Funds	Person-years		Funds
	Prof.	Total	$ 000	Prof.	Total	$ 000
CFS Headquarters	38	76	2 650	30	51	4 447
Newfoundland Forestry Centre	26	66	2 500	25.8	55.8	2 664
Maritimes Forestry Centre	44	150	3 990	46	107	5 080
Laurentian Forestry Centre	39	122	3 430	40	92.5	4 349
Great Lakes Forestry Centre	45	154	4 230	53	134.7	6 677
Northern Forestry Centre	44	119	3 670	52	102.5	4 851
Pacific Forestry Centre	56	162	4 690	62.8	133.9	6 549
Petawawa National Forestry Institute	44	127	3 500	60.5	114.5	6 251
Forest Pest Management Institute	32	87	2 500	34	85	3 977
Total	**368**	**1 063**	**30 390**	**404.1**	**876.9**	**44 845**

Grants and Contributions Administered by CFS HQ

	1979/80	1985/86
Forintek	4 600	4 400
Forest Engineering Research Institute of Canada	1 000	1 400
Energy from the Forest (ENFOR)	4 220	1 040
Human Resources Program (total)		(4 589)
University Forestry School Block Grants	290	2 289
Scholarships		580
Program for research by universities in forestry (PRUF)		1 500
Post-doctoral Fellows		220
Forest Economics Policy Analysis Project (UBC)		500
Canadian Interagency Forest Fire Centre (CIFFC)		100
International Energy Agency		172
Other (CFA, CFI, etc)	60	72
Sub total	**10 170**	**12 273**
Grand Total	**40 560**	**57 118**

Table 18. Canadian Forestry Service Minor Capital Funds in 1985/86[a]

Establishment	Minor Capital $(000)		
	Equipment	Maintenance	Total
CFS Headquarters	2 578	114	2 692
Newfoundland Forestry Centre	924	60	984
Maritimes Forestry Centre	1 473	56	1 529
Laurentian Forestry Centre	1 269	47	1 316
Great Lakes Forestry Centre	1 402	7	1 409
Northern Forestry Centre	908	542	1 450
Pacific Forestry Centre	1 825	34	1 859
Petawawa National Forestry Centre	1 273	629	1 902
Forest Pest Management Institute	883	83	966
Total	**12 835**	**1 572**	**14 107**[b]

[a]The totals include $768 in minor capital funds shown in the CFS Research and Technical Services budget.
[b]$1 618K of this total was used to cover the 1985/86 capital cut.

Table 19 shows the cash flow for major capital developments. Three of the forestry centres are receiving major additions to their office and laboratory facilities and an entirely new complex is being built to house the Maritimes Forestry Centre (all now completed). Although these capital developments are welcome and that in the Maritimes was urgently needed, they were initiated under the previous government as bricks and mortar, employment creation projects and not primarily as support for forestry.

Table 19. Canadian Forestry Service Cash Flow of Major Capital

Establishment	Previous	Expenditures ($000) 85/86	86/87	87/88	88/89	Total
Maritimes Forestry Centre[a]	955	4 683	12 969	3 893	–	22 500
(incremental operating funds)	–	(54)	(112)	(663)	(920)	(1 749)
Laurentian Forestry Centre	3 456	4 688	5 038	2 264	1 654	18 100
Great Lakes Forestry Centre	10 565	5 000	1 865	–	–	17 430
Pacific Forestry Centre	9 755	4 245	–	–	–	1 400
Total	**24 731**	**19 616**	**19 872**	**6 157**	**1 654**	**72 030**

[a]The MFC was originally shown as a major capital project, but the funds were transferred from Capital to Grants and Contributions in 1985/86.

Table 20 shows the distribution of the CFS research budget by program activity exclusive of the funds under grants and contributions which are shown in Table 17 but are transfer payments to other research agencies, such as Forintek, FERIC, etc.

Table 20. Canadian Forestry Service Staff and Expenditures, for Research, Technical Services and Economics 1985/86.

Person-years Activity	Person-years Prof.	Person-years Support	Expenditures $(000)
Program management	24.2	33.7	2 140
Research support	44.4	177.1	10 571
Forest environmental research[a]	0.1	0.1	45
Envir. factors & for. practices	16.2	29.2	1 323
Atmospheric pollutants	12.0	125.4	1 517
Major capital developments	0.1	0.1	7
Forest and plant ecology	11.1	19.1	873
Subtotal	**29.5**	**73.9**	**3 766**
Forest production research			
Tree seed & improvement	23.1	55.6	2 493
Reforestation	31.2	57.3	2 748
Tree and stand growth	20.6	39.1	1 811
Management systems	19.7	28.8	1 414
Subtotal	**94.6**	**180.8**	**8 466**
Forest protection research[a]	6.0	7.0	564
Fire	21.6	36.5	1 687
Pest biology	47.0	94.4	4 375
Pesticides & herbicides	17.4	38.6	1 642
Integrated biological control	29.2	59.9	2 830
Subtotal	**121.2**	**236.4**	**11 098**
Non-consumptive forest use	–	–	–
Forest utilization			
ENFOR	3.7	4.9	233
Solid wood research	0.2	0.2	8
Forest engineering	1.0	1.0	37
Codes & standards	0.8	0.8	430
Subtotal	**5.7**	**6.9**	**708**
Forestry Services			
For. insect & disease survey	20.7	87.5	3 868
Forestry data	4.2	18.1	991
Technology transfer	13.6	26.5	1 361
Grants & contributions	0.4	0.4	46
Subtotal	**48.9**	**132.5**	**6 266**
Economics	25.6	35.6	1 829
Total	**404.1**	**876.5**	**44 844**

[a]HQ staff administering programs

Federal/Provincial Agreements

Forestry development agreements of one sort or another exist between the federal government and all ten provinces. These are tailored to the individual requirements of each province, but usually emphasize reforestation, stand tending and forest protection. They all include funding for applied research and technology transfer, some which is usually conducted separately by the CFS and provincial forest service and some jointly.

In the Prairie Provinces for example, the agreements have provided about $4 million annually for forestry R&D ($2 million for forest management and $2 million for solid wood products research). This incremental funding also supplies salary and operating money for 15 CFS positions in the Northern Forestry Centre.

The additional staff and money allow the CFS Forestry Centres to increase the scope of high priority research. The agreements have also increased the interaction between federal and provincial agencies, industry and the universities. On the negative side, however, planning and implementing these programs reduces the Centres' ability to conduct their regular research work because of the need to involve many scientists in these initiatives. Morever it tends to balkanize the research activities of the CFS as a whole because the research funded by the agreements is planned and conducted with little or no input from the CFS Forest Science Directorate.

Expenditures vary somewhat from year to year. In 1985/86, they were approximately $9.8 million (Appendix 2 gives the detailed expenditures by province). Some similar research spending probably occurred in 1979/80 with funds from the federal/provincial general development agreements,but no data on this are available.

Table 21. Forest Research Expenditures funded by the Federal/Provincial Forestry Agreements

Research Activity	Expenditures $(000) 1979/80	1985/86
Forest environment	..	1 241
Forest production	..	3 763
Forest protection	..	1 438
Non-consumptive uses of the forest	..	–
Forest utilization	..	2 247
Forestry services	..	947
Economics	..	172
	..	9 808

Industrial Research Corporations

Pulp and Paper Research Institute of Canada (PAPRICAN)

PAPRICAN is a non-profit research and educational institution. It is operated by a 20- member board of directors, 14 of whom are appointed by the Canadian Pulp and Paper Association (CPPA), three by McGill University, one by the University of British Columbia (UBC), and two by the federal government.

The Institute maintains laboratories at Pointe Claire (Quebec) and on the UBC campus, both of which were provided by the federal government. McGill University also makes the former Institute building on its campus available to students identified with the Institute. PAPRICAN's resources in staff and money appear below (5,6):

	Staff numbers		
	1979	1980	1985
Professional	..	111	126[a]
Technical	..	130	139
Other	..	54	61
	39	**295**	**326**

	Revenues and expenditures $(000)		
	1979	1984	1985
Revenues	..	17 010	19 609
Expenditures	9 950	16 580	19 037

[a]Includes 4 postdoctoral fellows.

The 55 maintaining member companies provide most of the revenue, but in 1985 PAPRICAN did receive some financial or other tangible support from 26 companies in allied industries. It also received $1.4 million in NRC and other federal grants to its operating budget. In 1983, the federal government committed $15 million for construction of its new laboratory at UBC and $2 million for an addition to its Pointe Claire laboratory for research in biotechnology; this construction was scheduled for completion in 1986. At present, the UBC lab has only a small staff.

PAPRICAN conducts research that no single company could justify doing alone. Thus it has a strong program of fundamental studies while also being able to carry forward from inception to commercialization major developments of interest to the industry. Suggestions for research come from the staff, supporting companies, and committees of the CPPA Technical Section. After internal review, proposals go to its Research Program Committee for review and approval.

The range of scientific and engineering disciplines covered by the Institute staff includes: chemistry, chemical and mechanical engineering, biology, electronics, metallurgy, physics, mathematics, electron microscopy, process control and information science. The current major areas of research activity are: chemical pulping and bleaching, mechanical pulping, paper making, materials development, environmental and biological sciences, systems engineering, and technological forecasting. Research projects are grouped under the headings: improving productivity, improving process control, plant maintenance, ensuring an economic fibre supply, product development, conserving energy and non- renewable resources, improving the environment, and strategic basic research.

PAPRICAN also maintains an excellent pulp and paper library, provides computer-based information retrieval services, gives seminars, provides calibration services and standards, distributes technical reports, offers research consultation, and does contract research in the pulp and paper and allied fields.

The Institute's association with McGill began in 1925 and continues to be a highly successful venture in educational cooperation between an industry and a university. McGill admits students to its Faculty of Graduate Studies and Research, who conduct their thesis work under the direction of Institute staff, with the University granting the degrees. In this way McGill has done fundamental research highly important to the industry without compromising its high standards for postgraduate degrees.

PAPRICAN began a similar collaborative program with the Faculty of Applied Science at UBC in 1979. In January 1986, the UBC Pulp and Paper Centre, consisting of 32,250 ft^2 of laboratories and offices, was officially opened to house this program. UBC constructed the Centre with a $6-million grant from the province and the Institute supplies part of the staff and funds for operating and scholarships.

The Institute is undoubtedly a highly successful industrial cooperative research organization. Despite the recession of the early '80's, it has managed to add 27 people to its continuing staff and increase its annual budget from $9.9 million in 1979 to $19 million in 1985. This amounts to an increase of $2.7 million in 1985 dollars. It provides a range of research and services well beyond the capacity of any of its member companies. Its program, however, is of necessity aimed at the needs of the industry as a whole, and should not be regarded as a substitute for internal research programs by those companies able to afford them. Several company officials did say that they got a better return from the dollar spent in their internal research than from that contributed to PAPRICAN.

Forest Engineering Research Institute of Canada (FERIC)

FERIC is a non-profit research and development organization. It was established jointly by industry and the federal government in 1975 "to conduct research and development aimed at improving the efficiency of wood harvesting operations and minimizing the cost of wood used in the manufacture of forest products." Initially its program was concentrated on the harvesting and transport of wood. In 1981, however, mechanization of silviculture was added to its mandate and in 1986, the provinces agreed to fund a third of this latter program (6). FERIC now also conducts research on harvesting techniques appropriate for woodlots.

The Institute is operated by a 16-member Board of Directors, 11 of whom are appointed by the 45 supporting companies, three by the federal government and one by the university forestry schools. Presumably provision will now be made for provincial representation on the Board. FERIC consists of a Headquarters and Eastern Division which are based in Pointe Claire, Quebec and a Western Division based in Vancouver. The work program is developed under the guidance of the National Advisory Committee on Forest Engineering Research, which is appointed by the Board of Directors.

FERIC's resources have grown from a staff of 25 professional person-years and a budget of $2 million in 1979 to 57 engineers, foresters, technicians and support staff (34 in Pointe Claire and 23 in Vancouver) and $5 million in 1986 (see Table 22).

Table 22. FERIC's Estimated Revenues and Expenditures 1985-1989 (7,8).

	Amount (in 1985 $000)				
	85–86[a]	86–87	87–88	88–89[b]	89–90[b]
Revenues					
Industry members	1 688	1 895	2 050	2 250	2 425
Federal government	1 601	1 799	2 050	2 250	2 425
Provinces	–	230	285	364	383
Contract research	547	602	600	600	600
Other	267	429	375	300	300
	4 103	**4 955**	**5 360**	**5 764**	**6 183**
Expenditures					
Extraction & processing		1 415	1 738	1 888	2 050
Transportation		845	1 175	1 263	1 319
Mechanization of silviculture		690	855	1 092	1 149
Woodlot technology		224	370	419	494
Other		1 302	778	800	800
Capital budget		121	188	139	104
Total		**4 597**	**5 104**	**5 601**	**5 916**

[a]Fiscal year ending March 31.
[b]FERIC's projections.

As Solandt pointed out in 1979, FERIC has neither the staff nor budget to undertake extensive equipment development on its own. It must act as a catalyst to bring new ideas and equipment into industrial use.

Much of its present effort is directed towards making harvesting (felling, processing and skidding logs to the roadside) more efficient (9). Major projects are aimed at increasing the efficiency and utilization of current logging equipment, at developing new methods and equipment to reduce logging costs, at improving operator comfort and safety, and at minimizing adverse environmental impacts of logging. The objectives of research on road construction are to reduce building and maintenance costs while improving harvesting and transport operations. Research in transportation is currently concentrated on trucking wood from the roadside to the mill or sort yard. Truck hauling must become more efficient to offset the cost of energy and increasing distance of haul.

The objectives of the program on mechanization of silviculture are to:

- promote and conduct the development of silvicultural equipment and tools where needs have been identified;
- improve the ergonomic and safety aspects of silvicultural operations; and
- increase user knowledge of existing technology.

Current projects cover site preparation, planting, thinning and site tending. Evaluating the biological aspects of mechanization and nursery operations are not part of FERIC's mandate at present.

In eastern Canada, much industrial wood comes from privately owned forest land. FERIC's woodlot research is aimed at evaluating and developing technology for effective logging and silvicultural operations on small scattered private holdings.

As Solandt also pointed out, striking opportunities are available for Canadian manufacturers to replace imports in heavy logging machinery. So far FERIC has not been able to encourage growth of a major Canadian equipment industry. A similar opportunity exists in the mechanization of silviculture, which is a rapidly expanding activity. FERIC's terms of reference and budget may simply be inadequate to allow it to give such encouragement. This should be looked into.

Forintek Canada Corp.

Until April 1979, the Western Forest Forest Products Laboratory on the UBC campus in Vancouver and the Eastern Forest Products Laboratory in Ottawa were part of the Canadian Forestry Service. They were 'privatized' to form Forintek Canada Corp., which operates as a non-profit research organization controlled by a 22-member Board of Directors drawn from industry, the federal and provincial governments and the universities. Its funding comes from the federal and provincial governments and industry. These sources are discussed briefly below (10).

Federal

The Forest Development and Research Act (1966) and the Government Organization Act (1981) give the CFS specific responsibilities for research in forest resource use, wood product codes and standards, education and technology transfer. Much of this mandate has been delegated to Forintek. For the 5-year period ending March 1984, the CFS provided roughly half of Forintek's core budget (ca. $4 million annually). A further agreement provided $13.2 million ($4.4 million annually) for funding Forintek work in the area of CFS responsibility from 1 April, 1984 to 31 March, 1987. Treasury Board approval for renewal of support has recently been given. In addition, the CFS made a one-time grant of $1.5 million in 1983 to replace obsolete equipment. Forintek also receives considerable contract support from the CFS, DRIE, EMR and NRC.

Provinces

British Columbia has supported Forintek since its inception in 1979 with a $1.45 million contribution annually. More recently, Alberta established a proportional contribution, which it has subsequently enlarged through directed contract research under the Alberta/Canada Forest Resource Development Agreement. Saskatchewan and Manitoba are exploring the possibility of directed contract research. Ontario gave Forintek a large 3-year contract for research on product development from hybrid poplar. This ended in 1985 and negotiations are in progress to reestablish support from Ontario.

Quebec has given strong support for Forintek's Sawmill Improvement Program (SIP) and also sends an annual contribution to the general program. Discussions are well advanced on a contribution agreement for the next three years. Support from the Atlantic Provinces has been sporadic.

To summarize, provincial support to Forintek has been uncommitted from year to year, uncertain in its program needs, and except for British Columbia and Alberta highly volatile and undependable.

Industry

Until 1983, industry funding came mainly through contributions from a few large companies. Forintek now works largely through eight large timber associations, such as the Council of Forest Industries of British Columbia, and relies upon them to put pressure on their members to contribute. Essentially, contributing member companies represent about 75% of Canadian lumber production and 80% of panel board production, and pay 15/¢/mfbm or its equivalent.

In brief, the federal government (CFS) pays about 50% of Forintek's core budget and the provinces and industry pay about 25% each. Some 30 to 35% of the total budget comes from contracts, which allow Forintek to compensate for fluctuations in industry payments owing to markets. More than this amount of contract research tends to unbalance the program.

Table 23 shows Forintek's financial picture for 1985 and 1986 (11).

Table 23. Forintek's Revenues and Expenditures for 1985 and 1986[a]

	Amount ($000)	
	1985	1986
Revenue		
Contributions	7 854	8 439
Contract fees	3 325	3 250[b]
Other income	237	215
	11 416	**11 904**
Expenditures		
Salaries & wages	7 498	8 157
Lab operation	1 506	2 004
Premises[c]	1 035	923
Administration	587	638
	10 626	**11 722**
Capital fund[d]	4 413	4 517

[a]Fiscal year ending 31 March.
[b]$960K from the CFS mostly for the Light Frame Structures Research Program.
[c]Cost of renovations and short-term improvements.
[d]Fixed assets and depreciation.

These figures compare with a budget of about $8.8 million in 1979/80, or nearly $15 million in 1985/86 dollars. Forintek's research expenditures have thus not kept pace with inflation. The decrease in real expenditures was owing in part to the haste in which the two forest products laboratories were privatized and in part to the recession of the early 1980's. The federal Treasury Board has recently incorporated in the A-base budget of the CFS $4.6 million in core funding and $0.4 million for contract research for Forintek. What effect the new 15% export tax on lumber will have on industry contributions is uncertain -probably not much as long as housing starts remain high in North America. Should the demand for lumber weaken and the Canadian dollar gain strength, however, some companies may decide that they can no longer continue their support.

Program

Until 1982, Forintek was struggling to survive and contract research was stressed, frequently to the detriment of work for the core contributors from government and industry. In 1983, a fundamental shift in program philosophy was introduced. A planned program of attrition reduced the staff from 210 to 185. Some projects and programs were abandoned. In 1984, the Research Program Committees were rejuvenated, and a new strategic planning process led to a more sharply focused mission for the corporation, including its first set of corporate objectives.

The current program strategy has five parts:

- Resource Characterization: to act as a technological bridge between the forest managers who are to produce the timber resource and the mills that will use it to ensure that value is the quantity that tomorrow's forest will maximize and that mills adapt to the use of second-growth timber.

- Productivity: to introduce technology advances that will increase yields while holding down manufacturing costs.

- Technical Support to Marketing: to provide independent technical expertise to codes and standards agencies in domestic and export markets for Canadian wood products and wood systems.

- Opportunities with Wood: to generate new processes, products and markets for the Canadian wood products industry.

- Human Technical Skill Development: to provide courses, seminars and education programs to assist the industry establish the level of technology needed to remain competitive.

As part of its program to increase human skills, Forintek is endeavouring to develop closer relations with the universities. For example, it is offering a number of graduate scholarships at UBC and elsewhere in departments such as engineering, chemistry and forestry. It is also trying to set up a mini-Forintek at Laval in which the university will supply 10 to 15 graduate students and the laboratory facilities while Forintek and the Quebec government supply funding. The chief difficulty is in finding good Canadian students to accept the scholarships. Part of the problem is that industry is not hiring researchers.

Space precludes discussion of the detail of the research program. According to Forintek's analysis, however, a conservative estimate of the benefit/cost ratio of the $41 million invested in its program since 1982 is 5:1 in hard benefits, i.e. those that are immediate, evident and can be expressed in dollars. For 1985, the ratio was 10:1. The Canadian effort in solid wood research is grossly inadequate. Materials such as ceramics, steel, concrete and aluminum are making serious inroads into wood's traditional markets in the construction industry. New, better and cheaper wood products are needed to offset this challenge. Moreover, the forest industry is facing major structural change. Wood is becoming more expensive and the transition from old growth timber to second growth means not only that the raw material is of lower quality, but also that processing must adapt to the changing

wood supply. Despite this challenge and the evident returns from research, the investment in R&D for the whole Canadian solid wood industry is about 0.6 cents per sales dollar. The United States and Japan are spending two to two and a half times as much and Scandinavia over three times as much on research per sales dollar as Canada.

Research in the Forest Industry

Trying to determine industry's expenditures on research in the forestry sector is like trying to nail jelly to the wall. Industry is very reticent about giving figures and the basis of those available is uncertain.

Statistics Canada gives the following data for industrial intramural research in wood and pulp and paper, but gives no subject breakdown.

	Amount ($ millions)					
	1970	1975	1980	1982	1984	1985
Operating	21	28	60	68	75	79
Capital	3	3	5	8	12	12
Total	**24**	**31**	**65**	**76**	**87**	**91**
Constant $ 1971		19	25	23	24	24

Statistics Canada 88-001-V.9.

Table 24 gives the best detail available for this report. Figures for 1979 come from Solandt (1979) and include expenditures for only eight major companies known to have R&D programs. The 1985 figures come from a variety of sources. Most are based on a survey by the Research Committee of the CPPA Technical Section and include estimates for 11 large integrated companies. Unfortunately, the survey only gives precise figures for staff and a breakdown of activities by percentages. Actual R&D expenditures have been based on the assumption of $150K per professional, a figure that seems reasonable based on the actual returns of three companies that answered questionnaires. The data in Table 24 for 1985 largely represent expenditures by only 15 companies.

Only one company gave a precise breakdown of its spending on forestry research. $1,444K of the total is the amount that the NB Executive Research Committee estimates the industry spent directly on tree improvement, growth and yield studies, and resource information management systems.

Solandt's figures are not strictly comparable with those given in this report for 1985, but expressed in 1985 dollars they would amount to $39 million compared with $43 million in 1985. Combined with the data from Statistics Canada, they strongly suggest that industry's expenditures on research are falling in real terms. This impression is further supported by the figures below on the research manpower of 11 large integrated companies in 1980 and 1985.

Year	Professional	Technical	Other	Total
1980	278	221	119	618
1985	243	188	77	508

Table 24. Forest Industry Intramural R&D Expenditures in $(000) in 1979 and 1985[a]

Activity	1979	1985
Forestry	1 330	4 366
Wildlife	--	53
Logging	660	323
Pulp and Paper	17 000	15 953
Paper and board	..	11 181
Packaging	..	1 215
Solid wood products	3 400	4 656
Environmental[b]	..	1 771
Miscellaneous	650	3 199
Total	**23 040**	**42 717**

[a]In addition to the above operating expenditures two companies listed capital expenditures of $5671K in pulp and paper research.
[b]Largely research on treatment of mill waste.

In his comments on industry research in 1979, Solandt stated: "The R&D that is reported appears to be aimed at solving the relatively short-term problems of an individual company. Purists would probably not agree in calling it all research. Much of it is straightforward engineering development and process improvement. However, almost all of it does involve experimentation in the sense of trying something that is new to the company or even to Canada." These remarks are still true. Only two or three companies have maintained longe-range programs and several years ago one of these had to cut its research staff by 40%.

The tabulation below shows the research activities engaged in by the companies included in the survey by the CPPA Technical Section Research Committee.

Research activity	No. of companies
Forestry	5[a]
Pulp	9
Paper and board	11
Packaging	5
Solid wood products	3
Logging engineering	1
Environment	5
Other	9

[a]Only three companies had more than token forestry programs.

The prospects for more industry spending on research depends on the prosperity of the sector. The record, however, does not inspire much confidence in the idea of privatizing public research programs.

Research related to Forestry at Canadian Universities

Fifty-nine universities and colleges (42 English and 17 French) were included in the survey. In addition to the six well-established university faculties of forestry, 35 universities have research related to forestry and forest products in progress.

Total funding for forestry research at Canadian universities apparently increased from $3.9 million in 1978/79 to $21 million in 1985/86, while that in the forestry schools increased from $2.2 million to nearly $13 million (Table 25). The real increase in research funding at the faculties other than forestry was probably less than these figures suggest because the coverage for 1985/86 was considerably more comprehensive than that in 1978/79. Nevertheless, a very large growth in support has occurred beyond that attributable to inflation.

Most of the increase in funding came from the federal government, notably the CFS and NSERC (Tables 26 and 27). Federal funding amounted to $13 million of which $7.3 million went to the schools of forestry, where it had a marked effect on graduate student enrollment. Much of this money came from the CFS Human Resources Program, which has since been transfered to NSERC and will be phased out over the next four years.

The provinces are the next largest source of research support, contributing about $5 million in 1985/86. Among the provinces, Quebec was by far the most generous, devoting about $1 million annually to university research subventions. Industry gave only $900K in research support to the universities and over half of this went to faculties other than forestry, usually to chemistry and engineering departments.

The apparent research budgets for the forestry schools is somewhat distorted by the fact that Laval charged nearly $1 million in faculty salaries against its research in a way that made its separation from other sources of funding impossible. Had similar allowances for faculty salaries been

made for the other schools, the total research funding would probably have been about $4 million greater.

Among the forestry schools, Lakehead is clearly the weakest in research. If its million- dollar capital grant for lab and office space is subtracted, its research budget only amounted to $774K. Several other schools, e.g. UBC and UNB, are having considerably more success than in the past in competing for NSERC and other non-CFS support, and may be gaining parity with other more well-established research oriented faculties.

As Table 28 shows, the forestry faculties conduct the majority of research in traditional forestry areas, such as forest production and fire control. Other faculties do better in forest utilization, particularly pulp and paper.

Table 25. Estimated Total Annual Funding of Forestry Research in Canadian Universities Within and External to the Six Schools of Forestry, 1978/79 and 1985/87

	Fiscal year $(000)	
Research conducted in	1978/79	1985/86
Schools of forestry	2 176	12 951
Other departments	1 808	8 116
	3 984	21 067
Percentage conducted in forestry schools	44	61

Table 26. Estimated Sources of Forestry Research Funding at Canadian Universities, 1985/86 ($000)

Faculties	Source of research funding					Total
	Federal	Provincial	Industry	Misc.	University	
Forestry Faculties						
UBC	2 087	249	178	–	19	2533
Alberta	1 042	393	64	10	46	1555
Lakehead	679	1 086[e]	7	–	3	1 774[e]
Toronto	1 456	508	78	159[a]	–	2 201
Laval	860	1 194	45	435[b]	1 020[c]	3 555
UNB	1 183	94	25	21[d]	10	1 333
Total	**7 300**	**3 524**	**397**	**625**	**1 098**	**12 951**
% of forestry school funding	56	27	3	5	9	100
Other faculties (35 universities)	5 753	1 441	509	280	134	8 116
% of other faculties funding	71	18	6	3	2	100
Total	**13 060**	**4 965**	**906**	**905**	**1 232**	**21 067**
Percentage in forestry schools	56	71	44	67	90	61

[a]$154K from International Energy Agency (IEA).
[b]The source of this money could not be positively identified because of the way the original data were coded, but it is mostly federal money.
[c]Mostly faculty salaries - only Laval included them.
[d]$11.6K from IEA.
[e]Includes $1000K from Ont. Min. Colleges & Universities for major capital.

Table 27. Source of Funding for University Forestry Schools R&D 1985/86 ($000)

University	External support 1978/79	External support 1985/86	Source of support: Federal	Provincial	Industry	Misc.	University	Total
UBC	545	2 514	2 087	249	178	–	19	2 533
Alberta	358	1 509	1 042	393	64	10	46	1 555
Lakehead	196	1 774[a]	679	1 086[a]	7	–	3	1 774[a]
Toronto	202	2 201	1 456	508	78	159[b]	–	2 201
Laval	484	2 534	860	1 194	45	435[c]	1 020[d]	3 555
UNB	391	1 323	1 183	94	25	21[e]	10	1 333
	2 176	**11 855[e]**	**7 307**	**3 524**	**397**	**625**	**1 098**	**12 951**

[a]$1 million for building from the Ontario Ministry of Colleges and Universities, an $97.7 for equipment from the CFS.
[b]$154K from the International Energy Agency (IEA).
[c]Mostly federal money, but could not be identified positively because of the way the original data was coded.
[d]Mostly faculty salary.
[e]$11.6K from IEA.

Table 28. University Forestry Research Funding by Subject Area ($000)

Subject area	Average annual funding					
	1975/76 - 1977/78			1985/86		
	Forestry faculties	Other faculties	Total	Forestry faculties	Other faculties	Total
1. Environmental and biological studies						
Impact of forestry practices				227	146	373
Impact of atmospheric pollutants				712	192	904
Impact of major developments				15	28	43
Ecology and tree biology				1 594	1 597	3191
Subtotal	**381**	**279**	**660**	**2 548**	**1 963**	**4 511**
2. Forest production						
Tree seed and improvement				1 080	246	1 326
Biotechnology related to genetics				895	293	1 188
Reforestation				415	136	551
Tree and stand growth						
Silviculture	368	194	562	729	13	742
Mensuration				203	74	277
Remote Sensing	230	1	231	263	187	450
Management systems				240	30	270
Subtotal	**598**	**195**	**793**	**3 825**	**979**	**4 804**
3. Forest protection	253	406	659			
Fire				544	172	716
Pest biology						
- insects				230	607	837
- pathology				341	225	566
- mammals				–	2	2
Pesticides and chemical control						
- insects				48	563	611
- pathology				–	–	–
- plants (herbicides)				121	161	282
Integrated pest mgmt.				–	168	168
Subtotal	**253**	**406**	**659**	**1 284**	**1 898**	**13 182**

Table 28. University Forestry Research Funding by Subject Area ($000) (cont.)

Subject area	Average annual funding					
	1975/76 - 1977/78			1985/86		
	Forestry faculties	Other faculties	Total	Forestry faculties	Other faculties	Total
4. Non-consumptive uses of forest	191	222	413			
Wildlife				692	102	794
Recreation				24	11	35
Urban forestry				68		68
Rangeland				87		87
Subtotal	**191**	**222**	**413**	**871**	**113**	**984**
5. Forest utilization Enfor				198	874	1 072
Solid wood products & derivatives	894	126	1 020	453	269	722
Pulp and paper				560	1 571	2 131
Forest engineering	–	49	49	412	228	640
Subtotal	**894**	**175**	**1 069**	**1 623** (496)[a]	**2 942** (190)[a]	**4 565** (686)[a]
6. Forestry services						
Forest resource data	–	29	29	57		57
Technology transfer	–	–	–	50	118	168
Subtotal	–	**29**	**29**	**107**	**118**	**225**
7. Forest economics and policy	68	26	94	1 221	91	1 312
Total	**1 666**	**2 051**	**3 717**	**11 479**	**8 104**	**19 583**
Miscellaneous (scholarships, technicians, etc. not attributed to specific projects)				368	–	368
Major capital				1 098		1 098
Grand total	**1 666**	**2 051**	**3 717**	**12 945**	**8 104**	**21 049**

[a]Biotechnology in pulp and paper research.

Associations

The Canadian forestry sector is well served by associations of many kinds. As Solandt (1979) pointed out, the directory of associations in Canada published by the University of Toronto Press lists almost seventy. However, the Council of Forest Industries of British Columbia is the only one with an active research program, although many others play an important role in advising and encouraging and coordinating research in the sector.

COFI spends approximately $400K annually on solid wood research in its North Vancouver lab which is staffed by two researchers and four technicians. In past years, it funded indirectly up to $400K annually on environmental pulp and paper research. In 1984/85, COFI also funded $270K in health research conducted by the BC Research Council.

Summary

Table 29 summarizes Canada's operational expenditures on research related to forestry by agency. Apparent expenditures in 1979/80 were roughly $116 million, or $197 million in 1985 dollars. By 1985/86, they had risen slightly to $219 million.

During the past two or three years, the CFS has been in a catch-up phase in replacing obsolescent equipment and its minor capital funding of $12 million for 1985/86 was much higher than the average. Similarly the federal government initiated a makework program in construction about 1983, and the CFS major capital budget of $19.6 million in 1985/86 reflects this and distorts the normal picture.

Unfortunately the estimates of operational spending are low for both 1979/80 and 1985/86, contain some double counting and are not strictly comparable. The 1985/86 data do not include complete figures for industry's research and solid wood products, omit some federal and provincial research funding, and merely adjust for inflation the 1979/80 data for suppliers to industry. On the other hand, the coverage for government agencies, the universities and large integrated wood-using companies is more complete than in the Solandt report. It is thus possible that real expenditures on forestry research increased little if at all between 1979/80 and 1985/86.

On an agency by agency basis the picture is as follows. Real spending by the provinces has increased somewhat, particularly if their contributioons to the federal/provincial agreements are included. The spending by most provinces has just kept ahead of inflation and only Quebec and Albert have made major increases in their budgets. The figures for Ontario and British Columbia are deceptive because the coverage for both is considerably greater for 1985/86 than for 1979/80.

Meaningful comment is difficult about the efforts of the provincial research agencies because detailed figures were not available for CRIQ in 1985/86 and because the latter estimate includes three more agencies than in 1979. I suspect that both the 1979 and 1985 data give serious underestimates of the amount of relevant research performed by provincial research institutes.

The federal government is by far the largest performer in research related to forestry, but the extent of its dominance is concealed by the fact that much of the research it funds is performed in the universities, provincial and industrial research institutes and by industry on contract. The CFS is the largest single research agency and its operational funding and research manpower have declined seriously since 1979, although its capital funding has increased.

Among the industrial research agencies, the programs of PAPRICAN and FERIC have more than kept pace with inflation. Their real increases in spending, however, have been more than offset by the $3-million real dollar decline in the budget of FORINTEK.

The data are incomplete on research by industry, but all indications are that it has declined seriously since 1979. Only one company has anything like a comprehensive program in both forestry and products, and even it was forced to reduce its research staff greatly by the recession in 1981 and 1982.

The suppliers to the forest industry were not covered in this survey and it has been assumed that their real research expenditures remained the same as in 1979.

The bright picture has been in the universities where the real effort has tripled since 1979. Much of this increase has been owing to greater assistance from both the CFS and NSERC. How long it will remain bright is open to question, particularly in the forestry schools. The Human Resources Program of the CFs has been transferred to NSERC and will be phased out over a period of four years

on the assumption that forestry faculties should then be able to compete for research funds on a basis of equality with other science departments. This will probably be true for some of them. Unfortunately, unless the job market for forestry researchers improves, good graduate students in forestry may become rare.

Table 29. Canadian Expenditures on Forestry Research by Agency[a]

Province	Expenditures $(000) 1979/80	1979/80 (in 1985 dollars)	1985/86
Newfoundland	391	665	277
Prince Edward Island	–	–	490
Nova Scotia	500	850	1 033
New Brunswick	604	1 027	1 140
Quebec	2 345	3 987	7 571
Ontario	3 207	5 452	7 764
Manitoba	210	357	498
Saskatchewan	–	–	194
Alberta	414	704	1 260
British Columbia	5 480	9 316	9 212[b]
Total	**13 151**	**22 358**	**29 430**
Provincial Research Agencies			
Science Council of B.C.	718	1 221	1 513
CRIQ	4 553	7 740	1 700
Ontario Research Fundation	400	680	350
Alberta Research Council	..	–	800
NB Research & Productivity Council	..	–	49
NS Research Foundation	..	–	60
	5 671	**9 641**	**4 472**
Federal Agencies			
National Research Council	..	–	2 942
Environment Canada (less CFS)	250	425	1 142
Energy, Mines & Resources	1 400	2 380	3 600
Fisheries & Oceans	..	–	273
Agriculture Canada (less CFS)	900	1 530	2 320
Canadian Forestry Service	34 610[c]	58 837	44 845[d]
Unclassified	..	–	700[e]
	37 160	63 172	44 822
Federal/Provincial Agreements[f]			
Newfoundland	..	–	1 062
Prince Edward Island	..	–	350
Nova Scotia	..	–	114
New Brunswick	..	–	966
Quebec	..	–	1 304
Ontario	..	–	263
Manitoba	..	–	790
Saskatchewan	..	–	415
Alberta	..	–	2 527[g]
British Columbia	..	–	2 017
	..	–	9 808

Table 29. Canadian Expenditures on Forestry Research by Agency[a] (Cont'd)

Province	Expenditures $(000) 1979/80	1979/80 (in 1985 dollars)	1985/86
Industrial Research Agencies			
PAPRICAN	9 950	16 915	19 609
FERIC	2 000	3 400	4 103
FORINTEK Canada	8 800	14 960	11 416
	20 750	**35 275**	**35 128**
Industry Associations			
BC Council of Forest Industries	..	–	400
Integrated Forest Companies			
	23 040[h]	39 168	42 717[i]
Suppliers to the Industry			
	11 800	20 060	20 059[j]
Universities			
Forestry Schools	2 176	3 699	12 945
Other Departments	1 080	3 074	8 104
	3 984	**6 773**	**21 049**
Total	**115 556**	**218 804**	**218 885**
CFS Capital Funds			
Minor			11 721
Major			19 616
			31 337

[a]Data for federal and provincial governments do not include contributions to Forintek, etc., university subventions or contract research shown elsewhere.
[b]Includes expenditures of $1529K on fisheries, wildlife and range research related to forestry not covered in 1979.
[c]Includes $4220 in ENFOR funding.
[d]Operational funding only; does not include grants and contribution administered by CFS/HQ but shown elsewhere, or capital funds.
[e]Unidentified federal funding used for pollution control research in wood-using mills.
[f]Federal and provincial funds combined.
[g]Includes $1.8 million for contract research, some of which may be double counted in the Forintek budget.
[h]8 companies
[i]14 companies
[j]1979 figure adjusted for inflation

Part II - Canadian Research by Subject Area

Tables 30 to 37 show Canadian expenditures on forestry research by agency and broad research activity for 1979/80 and 1985/86. To make the figures comparable with those reported by Solandt (1), the reported expenditures have been multiplied by 1.5 for government agencies, 2 for universities and 1 for industry and industrial & provincial research institutes to show complete costs. The adjusted data for 1979/80 have been multiplied by 1.7 to convert them to 1985 dollars. Tables showing more detailed breakdown of expenditures in each broad research activity appear in Appendix 2.

Forest Environmental Research

This heading covers research on the environmental impacts of forestry practices, atmospheric pollutants and major capital developments as well as that in forest and plant ecology. The research activities included are comparable to those for which there were any actual expenditures in 1979 shown by Solandt under the heading *Environmental and Ecological Studies*. However, since Solandt did not usually subdivide his data into more specific subject areas, most of the 1979/80 expenditures are shown under *Forest and Tree Ecology*.

Table 30 summarizes spending on forest environmental research. Even allowing for inflation, total spending has increased, from roughly $17 million in 1979/80 (in 1985 $) to $26.6 million in 1985/86, with most emphasis being devoted to the environmental impact of forestry practices and the rather broad subject area of forest and plant ecology. Since 1979, considerable redistribution of research effort has occurred, but the universities have been responsible for most of the increase in spending.

The CFS is the principal actor in research on the environmental effects of forestry practices (logging, road construction, site preparation and so on), but the provinces and universities are now more active than in 1979. Growing public concern about the environmental impact of forestry and pressure for environmental impact assessment will stimulate demands for more research in this area.

Table 30. Expenditures on Forest Environmental Research Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	3 062	4 593	7 808	3 990	5 985
Cdn Forestry Service	2 810	4 215	7 166	5 347	8 020
Other federal agencies	..	..	..	1 175	1 762
Fed/prov agreements	–	–	–	1 241	1 861
Universities	660	1 320	2 244	4 511	9 022
Total	**6 532**	**10 128**	**17 218**	**16 264**	**26 650**
Research Activity					
Environmental factors and forestry practices	140	210	357	3 184	4 962
Impact of aerial pollutants	80	120	204	5 118	8 129
Impact of major developments	100	150	255	170	275
Forest and plant ecology	6 212	9 648	16 402	7 792	13 684
Total	**6 532**	**10 128**	**17 218**	**16 264**	**26 650**

[a]Federal and provincial government expenses have been multiplied by 1.5 and university expenditures by 2 to allow for overhead. The adjusted expenditures for 1979/80 have been multiplied by 1.7 to convert them to 1985 dollars.

Current research on the impact of atmospheric pollutants deals largely with acid rain, although there has been some work on the effects of sour gas and heavy metal pollution on vegetation. Hard evidence on the harmful effects of acid rain on forest vegetation and soil is still scanty for Canada, but there is almost unanimous agreement about their potential importance and the need for more research as well as remedial measures to reduce emissions of sulphur and nitrogen compounds.

Most of the forest research related to acid rain is being conducted from Ontario east. The principal actors are the CFS, the Atmospheric Environment Service and the Ontario Ministry of the Environment. The federal government has mounted a multi-agency research program entitled LRTAP (Long Range Transport of Aerial Pollutants). A recent program development by the CFS has been to extend its Forest Insect and Disease Survey to include an Acid Rain National Early Warning System. On over 100 permanent sample plots located in representative forests, the regular monitoring of forest health is being supplemented by special soil and vegetation analyses to detect possible changes.

During the 1970s, considerable study was given to the impact of major capital developments on forest land (eg. the proposed MacKenzie Valley Pipeline), but little such research is now in progress.

Forest and plant ecology covers basic research in forest soils and tree biology and the whole field of forest ecology insofar as these studies are not related to specific other objectives, e.g. soil studies on the maintenance of nursery soil fertility. It does not include biotechnology related to forest genetics. Owing to the way research was classified in 1979/80, it is difficult to say whether the apparent drop of $1.7 million in research spending is real or not. There probably has been a real decrease in the CFS effort devoted to subjects such as forest soils, tree physiology, silvics of natural regeneration, etc., not because such research is unimportant, but for lack of manpower.

Forest Production Research

Forest production research includes the fields of tree breeding and forest genetics, reforestation, tree and stand growth, and forest management systems. It covers the expenditures shown by Solandt under the headings of *Silviculture* and *Remote Sensing*.

Real expenditures increased by almost $20 million (in 1985$) between 1979/80 and 1985/86 (Table 31). Spending arising from the provinces, universities and federal/provincial agreements has increased, while that of the CFS decreased materially. In research activities, major increases occurred in forest genetics ($11.4 million), reforestation ($9.7 million) and management systems ($4.1 million), while spending in the traditional areas of tree and stand growth fell by nearly $5 million.

The man-made forest will be increasingly important in the future and the planting stock used to create it should be of good genetic quality. Much of the current research in tree and seed improvement is being devoted to biotechnology, including the first tentative steps in genetic engineering. Compared with funding for this sort of research in other fields of biology, the resources available for forestry are small and no dramatic payoffs should be expected in the near future.

Reforestation covers research in nursery practice, site preparation, and establishment and tending of young plantations. It also includes mechanization of reforestation except for the engineering aspects of equipment development. The volume of research has increased materially, with the provinces playing a leading role. Much of the work, however, is probably developmental in nature and not what the purist would call research.

Tree and stand growth is a grab bag category in the research activity structure of the CFS and covers much of the field of applied silviculture and mensuration, i.e. stand tending, fertilization,

growth and yield studies, modelling of tree and stand growth, and techniques in mensuration, inventories and remote sensing. Because of the importance of these subjects, the decline in research funding is alarming. Most of this decrease has occurred in the CFS program.

Management systems is another broad category of research activity. It includes modelling of management systems, multiple use forestry, silviculture systems and harvesting, small forest holdings and minor forest products (e.g. Christmas trees). Spending in this area increased from roughly $600K (in 1985$) in 1979 to $4.7 million in 1985. This increase, however, may be more apparent than real owing to the way expenditures were classified in 1979.

Table 31. Expenditures on Forest Production Research Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	8 179	12 268	20 856	18 624	2 7936
Provincial research institutes	1 057	1 057	1 797	1 214	1 214
Cdn Forestry Service	8 800	13 200	22 440	12 022	18 033
Other federal agencies	1 150	1 725	2 933	3 730	5 595
Fed/prov agreements	–	–	–	3 762	5 643
Universities	793	1 586	2 696	4 804	9 608
Industry	1 330	1 330	2 261	4 323	4 323
Totals	**21 309**	**31 166**	**52 982**	**48 479**	**72 352**
Research Activity					
Tree and seed improvement	6 014	9 021	15 336	17 354	26 701
Reforestation	3 367	5 050	8 585	12 169	18 283
Tree and stand growth	9 614	14 152	24 058	12 415	19 161
Management systems	236	354	602	3 063	4 729
Unclassified[b]	2 078	2 589	4 401	3 478	3 478
Total	**21 309**	**31 166**	**52 982**	**48 479**	**72 352**

[a]Conversion factors for overhead are 1.5 for government, 2 for universities, 1 for provincial research institutes and industry, and 1.7 for inflation.
[b]Largely industry.

Forest Protection Research

Table 32 summarizes research expenditures on protection against forest fires, insects and diseases. Despite the importance of forest protection and the vast sums spent to control damage, research expenditures are modest and increased by only about $5.5 million (in 1985$) between 1979 and 1985. Brief comments follow on the major activities, i.e. research on forest fire control, pest biology, pesticides and herbicides, and biological control.

In 1977, the CFS had a virtual monopoly in forest fire research in Canada and its program had just suffered heavy losses with closure of the Forest Fire Research Institute in Ottawa. During the past six years, the situation has improved in that additional funding is coming from the federal/provincial agreements and there is considerable activity in the forestry schools. In real terms, however, funding for the CFS program has declined even though the Service has been doing some excellent work, particularly in developing forest fire management systems. Despite the importance of forest fire control and the fact that it costs hundreds of millions annually, Canada is only spending about $4 million on it and has probably less than 30 professional researchers in the field.

Table 32. Expenditures on Forest Protection Research Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	806	1 209	2 055	2 711	4 066
Provincial research institutes	73	73	124	125	125
Cdn Forestry Service	10 670	16 005	27 209	15 759	23 638
Other federal agencies	780	1 170	1 989	1 854	2 781
Fed/prov agreements	–	–	–	1 438	2 157
Universities	659	1 318	2 241	3 182	6 364
Industry	..	..	..	43[b]	43
Total	**12 988**	**19 775**	**33 618**	**25 112**	**39 174**
Research Activity					
Fire	2 051	3 077	5 231	4 227	6 698
Pest biology	9 978	14 967	25 444	11 619	18 093
Pesticides and herbicides	300	413	702	4 322	6 908
Integrated pest management	..	..	..	4 944	7 475
Unclassified	659	1 318	2 241	–	–
Total	**12 988**	**19 775**	**33 618**	**25 112**	**39 174**

[a]Conversion factors for overhead are 1.5 for government, 2 for universities, 1 for provincial research institutes and industry; and 1.7 for inflation.
[b]Only one company reported.

Pest biology is another research area in which the CFS had a virtual monopoly in Canada until relatively recently. Its reputation in insect ecology was worldwide, but both the numbers and calibre of its staff are declining as experts retire and staffing limits preclude their replacement. Fortunately, both the provinces and universities are beginning to acquire more capability in this area. Unfortunately, however, effort is still declining in spite of the continuing ravages of pests such as the spruce budworm and mountain pine beetles, the arrival of the gypsy moth in Canada, and the threat of root rots in the growing areas of man- made forests.

It is difficult to say whether the effort in research on pesticides has increased materially since 1979 because it was included with pest biology and biological control in Solandt's report. The vast majority of research, however, is still conducted by the CFS, particularly in the Forest Pest Management Institute (FPMI), although activity is growing in the universities. Research on herbicides certainly is increasing. The program at the FPMI, for example, only began about 1980. The level of research is still far short of what would be desirable. It is worth noting that far more money has been spent on pest biology and biological control than on pesticides and herbicides in spite of the popular impression to the contrary.

There is general agreement that biological control and integrated management are the approaches most acceptable from an environmental point of view, and the ones that should be stressed in the future. Advances in this area depend largely on knowledge generated by research in pest biology and on pesticides. The CFS is the only agency in Canada with any appreciable program in the field.

Canadian efforts in the biological control of 21 forest insect pests have recently been evaluated (12). A third of these pests have been almost permanently controlled in their present environment and another third can be controlled for one or two pest generations before an additional treatment is needed. Benefit/cost data are scanty but very conservative ratios at 20:1 have been calculated for two successes with long-term control. Prospects for further successes in this area are bright.

Non-Consumptive Uses of the Forest

Apart from some unclassified activity in the universities, no expenditures for research on non-consumptive uses of the forests were recorded in 1979. Nevertheless, considerable work was in progress. The Canadian Wildlife Service and the provincial fish and game branches were undoubtedly conducting research on wildlife and fish habitat in forest land, and parks branches must have been doing some research on recreation. The University of Toronto, School of Forestry, had a chair in urban forestry and the CFS Forest Insect and Disease Survey devoted considerable attention to the problems of urban shade trees. Thus Table 37, which summarizes expenditures on research on the non-consumptive uses of the forest, gives the false impression of a major increase in activity in this area since 1979.

The figures for 1985/86 are themselves an underestimate of the current activity. They include, for example, data on relevant fisheries and wildlife research only from the provinces of New Brunswick and British Columbia, but there is considerable work being done in other provinces, particularly Ontario. There has, however, been a consid[illegible]e increase in the amount of wildlife research in the forestry schools, notably those at the [illegible]rsities of British Columbia and New Brunswick.

Forest recreation is a sadly neglected area in Canada. Forest land occupies about 58% of the area of Canada within the provincial boundaries and with the growing importance of tourism and public interest in outdoor recreation, more research on forest recreation is obviously needed.

Table 33. Research Expenditures on the Non-consumptive Uses of the Forest Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	..	..	..	1 937	2 906
Provincial research institutes	..	..	..	76	76
Federal agencies	..	..	..	76	114
Universities	413	826	1 404	984	1 968
Industry	–	–	–	53	53
Total	**413**	**826**	**1 404**	**3 126**	**5 117**
Research Activity					
Wildlife and Fisheries	..	..	..	2 758	4 470
Rangeland Management	..	..	..	265	441
Recreation	..	..	..	35	70
Urban Forestry	..	..	..	68	136
Unclassified	413	826	1 404	–	–
Total	**413**	**826**	**1 404**	**3 126**	**5 117**

[a]Conversion factors for overhead are 1.5 for government, 2 for universities, 1 for provincial research institutes, and 1.7 for inflation.

Forest Utilization Research

Table 34 shows the expenditures on forest utilization research. Some of these figures are undoubtedly underestimates. The data are poor, for example, for expenditures in 1985/86 by the provincial research institutes, the suppliers to the forest industry and by the solid wood products industry.

Energy from the Forest (Biomass)

Research in this area was almost entirely paid for by the bioenergy programs of the Department of Energy, Mines and Resources and NRC, and the ENFOR Program of the CFS. Expenditures by the provincial research institutes and universities largely represent contract research funded by the federal government.

Research falls into two general categories, namely biomass production and biomass conversion. As the name implies, biomass production deals with growing, measuring and harvesting forest biomass, and it was funded mainly by NRC and the CFS. Priority for this research is decreasing. NRC's bioenergy program was phased out during 1985/86 and funding for the ENFOR program had declined from $4.2 million in 1979/80 to roughly $1 million in 1985/86.

Forest biomass conversion deals with the gasification or liquefaction of wood and mill residues, and the testing of wood-burning stoves and furnaces. The Renewable Energy Branch of EMR underwrites most of this research and still attaches considerable importance to it. Its budget for 1986/87 was $6.5 million.

With the current low prices for oil and natural gas, lower priority for research on biomass as a source of energy was inevitable. Interest in it will probably pick up again during the latter years of the 90s.

Table 34. Expenditures on Forest Utilization Research Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	668	1 002	1 703	826	1 239
Provincial research institutes	4 541	4 541	7 720	3 057	3 057
Cdn Forestry Service	4 638	6 957	11 827	1 005	1 508
Other Federal agencies	500	750	1 275	4 142	6 213
Fed/prov agreements	–	–	–	2 247	3 370
Universities	1 069	2 138	3 635	4 565	9 130
Industrial research institutes	20 750	20 750	35 275	35 128	35 128
Industry	21 710	21 710	36 907	38 298	38 298
Industry suppliers	11 800	11 800	20 060	20 059[b]	20 059
Industrial associations	–	–		–400	400
Total	**65 676**	**69 648**	**118 402**	**109 727**	**118 402**
Research Activity					
Energy from the forest	5392	7 961	13 534	4 079	6 654
Solid wood products	18 978	18 978	32 263	27 024	29 219
Pulp and paper	33 105	33 105	56 279	61 202	64 026
Forest engineering	6 875	7 207	12 252	10 537	11 268
Miscellaneous	1 326	2 397	4 075	6 885	7 235
Total	**65 676**	**69 648**	**118 402**	**109 727**	**118 402**

[a]Conversion factors for overhead are 1.5 for government, 2 for universities, 1 for provincial research institutes and industry, and 1.7 for inflation.
[b]1979/80 expenditure converted to 1985 dollars.

Solid Wood Products

In 1979, Solandt recorded expenditures of $19 million in research on solid wood products ($32 million in 1985$). The level of research support in 1985/86 was roughly $29 million. Support for Forintek and industry's spending have declined. Only one of the major integrated companies has a comprehensive research program. According to the Research Committee of the CPPA Technical Section, the major integrated companies were devoting less than 6% of their research effort to solid wood products in 1985. In view of the inroads of other materials into the traditional uses of wood and the competition Canada faces from Scandinavia, the United States, Japan and New Zealand, this is not a happy state of affairs.

Fortunately, some of the slack has been taken up by research in the universities and funding of contract research through the federal/provincial agreements. DRIE and the Canadian Wood Council have been underwriting some research in Codes and Standards and some innovative work is in progress in several of the medium-sized special product and lumber companies, neither of which are included in this survey. In general, however, Canada is not conducting enough research in solid wood products, and in particular is not doing enough work on increasing the value-added of its products.

Pulp and Paper

Research expenditures on pulp and paper have increased by almost $8 million in real terms since 1979. PAPRICAN, the universities and NRC are rsponsible for most of the increase, but some double counting may be included in the data arising out of NRC's PILP and IRAP. Industry's in-house research has not kept pace with inflation. Considerable emphasis is now being given to biotechnology.

Forest Engineering

Unless the suppliers to the forest industry increased their 1979 levels of research, support for forest engineering research has not kept pace with inflation. The principal actors are the industry suppliers, the Forest Engineering Research Institute of Canada, and the universities. Forest industry support has dropped to less than a third of its 1979 level. One western company has contributed considerable money to research on balloon logging being conducted in the United States, which is not included here.

Miscellaneous and Unclasssified

In 1985/86, federal expenditures in this category amounted to $700K and were devoted to research on pollution control in the wood-using industries. Of the industrial spending, $1.2 million went on packaging research, $1.8 million on environmental studies (pollution control), and $3 million to miscellaneous unclassified research.

Forestry Services

Table 35 summarizes expenditures in forestry services. Although mostly not research, the activities covered here are closely related to it and do include some elements of research.

Forest Insect and Disease Survey

The Forest Insect and Disease Survey is Canada's early warning system for insect and disease problems in the woods. It was started about 1938 and is perhaps unique in the world. It has always

been predominantly a CFS activity. Quebec, however, has developed its own survey -the costs are buried in its forest protection budget and do not appear in this section. Other provinces are developing some capability to monitor severe insect and disease problems that have been identified, but none except Quebec has created a continuing formal survey unit.

Because of its relatively high staffing, the Survey has been suffering attrition for many years as pressure for manpower elsewhere has mounted. During the past six years, its budget has decreased by almost $1 million in real terms (Table 35), and its professional complement and capability are not nearly as high as they used to be. Any further attrition would be unwise.

Forest Research Data

This activity includes the forest resource data program of the CFS and research on data storage and retrieval. Table 35 also includes the expenditures shown by Solandt under *Forest Resource Survey and Appraisal*. As Solandt pointed out in 1979, however, considering the accuracy of surveys and inventories of all kinds, it is amazing that expenditure in this field is so small.

Technology Transfer

Solandt's report did not include a section dealing specifically with technology transfer, although it does discuss dissemination of forestry information and bibliographic data bases. Since 1979, this function has received more explicit recognition. All of the CFS regional forestry centres have units whose purpose is technology transfer. The federal/provincial forestry agreements make some budgetary provision for it. Ontario, however, is perhaps the most progressive in this area and has opened three Technology Development Units expressly for the purpose of technology transfer, although not exclusively for forestry.

On the question of forestry information, Solandt pointed out that the problem is not access to literature, but rather some means of identifying the important information without working through the entire literature. In this context, the CFS did make several proposals to establish a technical information unit to help guide the practicing forester and resource manager to the information he needs, but they were rejected for budgetary reasons. It would be useful to revive this idea. The CFS might also follow the lead of Agriculture Canada and establish a computerized Canadian Inventory of Forestry Research.

Although their expenditures are not included in this section, the industrial research institutes, PAPRICAN, FERIC and Forintek all consider technology transfer as one of their prime functions and all devote considerable effort and money to it.

Table 35. Expenditures on Forestry Services Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	436	654	1 112	4 757	7 136
Cdn Forestry Service	5 812	8 718	14 821	8 893	13 340
Other federal agencies	120	180	306	..	..
Fed/prov agreements	–	–	–	947	1 420
Universities	29	58	99	225	450
Total	**6 397**	**9 610**	**16 337**	**14 822**	**22 346**
Research Activity					
Forest insect & Disease Survey	3 640	5 460	9 282	5 560	8 340
Forest resource data	1 577	2 380	4 046	2 411	3 645
Technology transfer	1 180	1 770	3 009	6 619	10 012
Special grants	..	..	..	232	348
Total	**6 397**	**9 610**	**16 337**	**14 822**	**22 345**

[a]Conversion factors for overhead are 1.5 for government, 2 for universities, and 1.7 for inflation.

Economics

As Solandt pointed out, although economics research on forestry problems must be done widely throughout government, industry and the universities, the only actual expenditures identified as such were in the CFS and universities. As Table 36 shows, this situation still prevails.

In real terms, CFS spending on forest economics seems to have declined somewhat since 1979, but this is misleading. Roughly half the spending in the universities is going to the Forest Economic Policy Analysis project at the University of British Columbia, which is being largely funded by the CFS.

During 1980 and 1981, the capability of CFS headquarters in economics nearly vanished; it has been rebuilt to at least a respectable level. Altogether, the CFS has 25.6 professional and 35.6 support person-years in economics.

Table 36. Expenditures on Forest Economics, Adjusted for Overhead and Inflation[a]

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Cdn Forestry Service	1 880	2 820	4 794	1 829	2 744
Fed/Prov Agreements	–	–	–	172	258
Universities	94	188	320	1 312	2 624
Total	**1 974**	**3 008**	**5 114**	**3 313**	**5 626**

[a]Conversion factors for overhead are 1.5 for government and 2 for universities, and 1.7 to convert 1979/80 adjusted expenditures to 1985 dollars.

Summary

Tables 29 and 37 summarize Canadian operational expenditures on research related to forestry by agency and broad subject matter. (Tables 30 to 36 and Appendix 3 give more detail on expenditures within each of the subject areas.)

Total research expenditures for 1979/80 and 1985/86 were $245 million[1] and $289 million respectively in 1985 dollars, indicating an increase of $44 million in annual spending since 1979. In these figures, however, the cost of government programs has been increased by 50% and those of university by 100% to include the total cost of overhead and senior salaries.

In 1971, the Science Council of Canada (13) published the results of a comprehensive survey of Canadian research in forestry for 1968. Total expenditures then were $257 million in 1985 dollars. The comparable figures for 1979 and 1985 are $196 million and $219 million respectively, despite the fact that the latter two surveys covered more agencies than the Science Council study. In the meantime, the forest industry has expanded greatly in real terms and demands on the forest estate for uses other than industrial forestry have multiplied. Yet we are now giving less support to research in forestry than in 1968.

Canada's total research expenditures in 1985/86 were approximately $290 million (Table 37), which amounted to 0.9% of the value of shipments in 1984. On the same basis,, industry's in-house spending on research was less than 0.1% and its spending on forestry as opposed to forest products research was negligible. Total forest industry spending on research, including that of the industry suppliers and the industrial research institutes, amounted to only 0.3% of the value of shipments. Industry may have little choice in this matter, but figures such as these make one question the wisdom of privatizing any more government research programs.

1. A recompilation of the figures in Solandt's report suggests that this is more accurate than the figure of $240 million (in 1985 dollars) used in the report.

Table 37. Canadian Expenditures on Forestry Research by Agency and Research Activity

	Expenditures $(000)				
	1979/80			1985/86	
	Reported	Adjusted	In 1985 dollars	Reported	Adjusted
Agency					
Provinces	13 151	19 726	33 534	32 845[a]	49 267
Provincial research institutes	5 671	5 671	9 641	4 472	4 472
Canadian Forestry Service	34 610	51 915	88 256	44 855[b]	67 282
Other federal agencies	2 550	3 825	6 503	10 977	16 465
Federal/provincial agreements	-	-	-	9 807	14 710
Universities	3 717[c]	7 434	12 638	19 583[d]	39 166
Industrial research institutes	20 750	20 750	35 275	35 128	35 128
Industry	23 040	23 040	39 168	42 717	42 717
Industry suppliers	11 800	11 800	20 060	20 059	20 059
Industrial associations	..	..	..	400	400
Total	**115 289**	**144 161**	**245 075**	**220 843**	**289 666**
Research Activity					
Environmental	6 532	10 128	17 218	16 264	26 650
Forest production	21 309	31 166	52 982	48 479	72 352
Forest protection	12 988	19 775	33 618	25 112	39 174
Non-consumptive use of the forest	413	826	1 404	3 126	5 117
Forest utilization	65 676	69 648	118 402	109 727	118 402
Forestry services	6 397	9 610	16 337	14 822	22 345
Forest economics	1 974	3 008	5 114	3 313	5 626
Total	**115 289**	**144 161**	**245 075**	**220 843**	**289 666**

[a]Includes 3345K in subventions and contract research in Quebec and therefore involves some double counting.
[b]Does not include $19.6 million in major capital and $11.7 million in minor capital for 1985/86.
[c]Average university expenditure for 1975/76 to 1977/78.
[d]Does not include 368K miscellaneous expenditures and $1098 in major capital.

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Appendix 1. Forest Research in Canada 1985/86

Subject Classification

The subject classification used in this report is based largely on the activity list of the Canadian Forestry Service (CFS). Additional headings, however, are included to cover subjects not under research by the CFS. Funds under Program Management and Research Support have been shown in PART I for some agencies, notably the CFS itself and the Quebec and Ontario forest services, but these costs have been prorated to the research activities in PART II.

The CFS activity listing is by objective rather than discipline. Although this has some advantages, it does mean that research in the same disciplinary area may appear under several different headings. Forest hydrology, for example, can appear under Environmental Factors and Forestry Practices (watershed research in the Rocky Mountains) or under Environmental Impact of Atmospheric Pollutants (watershed research on acid rain).

Research Activities

1. **Forest Environmental Research**

   (a) *Environmental Factors and Forestry Practices*

   Research related to acid rain and the environmental impacts of pesticides and herbicides appears elsewhere.

   (b) *Environmental Impact of Atmospheric Pollutants*

   Includes acid rain and heavy metals research.

   (c) *Environmental Impact of Major Developments*

   (d) *Forest and Plant Ecology*

   Includes silvics, forest soils and tree biology research insofar as such studies do not relate to specific other objectives. For example, soil studies on the maintenance of nursery soil fertility would appear under Reforestation and biotechnology related to forest genetics appears under Seed and Tree Improvement.

2. **Forest Production Research**

   (a) *Tree Seed and Improvement Research*

   Includes the whole field of tree breeding and forest genetics.

   (b) *Reforestation*

   Includes nursery practice, seedling production, site preparation, establishment and tending of young plantations, and mechanization of reforestation except for the engineering aspects of equipment development.

(c) *Tree and Stand Growth*

Covers much of the areas of applied silviculture and mensuration, e.g. growth and yield studies, modelling of tree and stand growth, stand tending, site amelioration and fertilization, biomass production where this is aimed at tree growth, techniques in mensuration, inventories and remote sensing. Where possible silviculture and mensuration are shown separately.

(d) *Management Systems*

Forest management and regulation: modelling of management systems, multiple-use forestry, silvicultural systems and harvesting, small forest holding and minor forest products, etc.

3. **Forest Protection Research**

(a) *Forest Fire Research*

(b) *Pest Biology Research*

(c) *Chemical Pesticide Research*

Includes research on pesticides for insect, disease and animal control, herbicides and brush killers, and the environmental impact of these agents.

(d) *Biological Control and Integrated Pest Management*

4. **Research on the Non-consumptive Uses of the Forest**

(a) *Fish and Wildlife*

Includes only those aspects relating to the interaction between fisheries, wildlife and forestry.

(b) *Forest Recreation*

(c) *Urban Forestry*

(d) *Rangeland Management*

5. **Forest Utilization Research**

(a) *Energy from the Forest (Biomass)*

(b) *Solid Wood Products*

(c) *Pulp and Paper*

(d) *Forest Engineering*

Includes the engineering aspects of harvesting and the mechanization of silviculture, and ergonomics; the silvicultural or biological effects of mechanization fall largely under Forest Production Research.

(e) *Codes and Standards*

6. **Forestry Services**

   (a) *Forest Insect and Disease Survey*

   (b) *Forest Resource Data*

   Includes CFS Forestry Statistics Program and research on forestry data storage and retrieval.

   (c) *Technology Transfer*

   (d) *Grants and Special Contracts*

7. **Forest Economics and Forest Policy Research**

8. **Major Capital Expenditures**

   Buildings, laboratories and so on.

Symbols Used in Tables:

. . . figures not appropriate or not applicable.
. . figure not available
– nil or zero

Appendix 2. Research Funds Expended under Federal/Provincial Research Agreements

Tables 1-8 show research expenditures in 1985/86 under the federal/provincial forestry agreements.

Table 1. Research Expenditures Under the Canada/Newfoundland Forestry Subsidiary Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Forest production			
Tree seed and improvement	66	8	74
Reforestation	96	11	107
Subtotal	**162**	**19**	**181**
Forest protection			
Pesticides & herbicides	150	17	167
Biological control	12	1	13
Subtotal	**162**	**18**	**180**
Forest utilization			
Biomass conversion	277	31	308
Solid wood products	67	8	75
Forest engineering	9	1	10
Subtotal	**353**	**403**	**93**
Forestry Services			
Forest resource data	277	31	308
TOTAL	**954**	**108**	**1 062**

Appendix 2

Table 2. Research Expenditures Under the Canada/PEI Forestry Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Forest production			
Tree and stand growth	127	–	127
Forestry services			
Forest resource data	72	–	72
Technology transfer	151	–	151
TOTAL	**350**	–	**350**

Appendix 2

Table 3. Research Expenditures Under the Canada/Nova Scotia Forest Renewal Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Forest production research			
Reforestation	50	–	50
Tree and stand growth	2	2	4
Subtotal	**52**	**2**	**54**
Forest protection research			
Pesticides & herbicides	17	–	17
Biological control	17	–	17
Subtotal	**34**	–	**34**
Forestry services			
Forest resource data	5	6	11
Technology transfer	15	–	15
Subtotal	**20**	**6**	**26**
TOTAL	**106**	**8**	**114**

Appendix 2

Table 4. Research Expenditures Under the Canada/New Brunswick Forest Renewal Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Forest environmental research			
Forest and plant ecology	254	–	254
Forest production research			
Tree seed & improvement	153	83	236
Reforestation	59	40	99
Tree and stand growth	142	154	296
Subtotal	**354**	**277**	**631**
Forest protection research			
Pest biology	37	–	37
Biological control	13	–	13
Subtotal	**50**	–	**50**
Forestry services			
Technology transfer	7	24	31
TOTAL	**665**	**301**	**966**

Appendix 2

Table 5. Research Expenditures Under the Canada/Quebec Forest Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Forest production research			
Tree seed and improvement	15	–	15
Reforestation	41	42	83
Tree and stand growth	377	363	740
Subtotal	**433**	**405**	**838**
Forest protection research			
Forest fire	233	233	466
TOTAL	**666**	**638**	**1 304**

Appendix 2

Table 6. Research Expenditures Under the Canada/Ontario Forest Resource Development Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Forest environmental research			
Impact of forest practices	71	–	71
Forest production research			
Tree seed and improvement	62	29	91
Reforestation	45	–	45
Tree and stand growth	38	–	38
Subtotal	**216**	**29**	**245**
Forest protection research			
Forest fire	10	–	10
Biological control	7	–	7
Subtotal	**17**	–	**17**
TOTAL	**233**	**29**	**262**

Appendix 2

Table 7. Research Expenditures Under the Forestry Agreements between Canada and the Prairie Provinces 1985/86

Activity	Expenditures $(000) Man.	Sask.	Alberta	Total
Forest environmental research				
Forest and plant ecology	125	–	90	215
Forest production research				
Tree seed and improvement	25	–	130	155
Reforestation	120	120	–	240
Tree and stand growth	110	–	105	215
Subtotal	**255**	**120**	**235**	**610**
Forest protection research				
Forest fire	60	90	–	150
Pest biology	110	–	–	110
Pesticides & herbicides	50	–	160	210
Integ. pest management	–	–	110	110
Subtotal	**220**	**90**	**270**	**580**
Forest utilization research				
Solid wood products	–	–	1 800	1 800
Codes and standards	–	–	50	50
Subtotal	–	–	1 850	1 850
Forestry services				
For. insect & disease survey	–	5	–	5
Forest resource data	30	–	–	30
Technology transfer	50	60	70	180
Grants and special contracts	–	90	–	90
Subtotal	**80**	**155**	**70**	**305**
Economics	110	50	12	172
TOTAL	**790**	**415**	**2 527**	**3 732**
CFS person–years	6	5.3	6	17.3

Appendix 2

Table 8. Research Expenditures Under the Canada/BC Forest Development Agreement 1985/86

Activity	Expenditures $(000) Federal	Provincial	Total
Program management	21	19	40
Research support	40	136	176
Forest environmental research			
Environ. factors & forest practice	171	215	386
Environ. impact of major development	7	7	14
Forest and plant ecology	122	104	226
Subtotal	**300**	**326**	**626**
Forest production research			
Reforestation	117	244	361
Tree and stand growth	40	364	404
Management systems	130	129	259
Subtotal	**287**	**737**	**1 024**
Forest protection research			
Fire	16	14	30
Pest biology	16	15	31
Herbicides	19	19	38
Subtotal	**51**	**48**	**99**
Forest utilization research			
Codes and standards	–	4	4
Technology transfer	48	–	48
TOTAL	**747**	**1 270**	**2 017**

Appendix 3. Detailed Research Expenditures by Research Activity

Table 1. Forest Environmental Research

Table 2. Forest Production Research

Table 3. Forest Protection Research

Table 4. Research on Non-consumptive Uses of the Forest

Table 5. Forest Utilization Research

Table 6. Forestry Services

Key to symbols

... figures not appropriate or not applicable
.. figure not available
– nil or zero

NOTE: The university data under 1979/80 are actually the average expenditures for 1976 to 1978.

Appendix 3

Table 1. Expenditures on Forest Environmental Research

Agency	Expenditures $(000) 1979/80[a]	1985/86
Environmental Factors and Forestry Practices		
Provinces	140	269
Canadian Forestry Service	..	1 901
Other federal agencies	..	138
Federal/provincial agreements	–	503
Forestry schools[b]	..	227
Other faculties[b]	..	146
	140	3 184
Environmental Impact of Aerial Pollutants		
Provinces	80	996
Canadian Forestry Service	..	2 181
Other federal agencies	..	1 037
Forestry schools[b]	..	712
Other faculties[b]	..	192
	80	5 118
Environmental Impact of Major Developments		
Provinces	100	101
Canadian Forestry Service	..	10
Federal/provincial agreements	..	16
Forestry schools[2]	..	15
Other faculties[b]	..	28
	100	170
Forest and Tree Ecology		
Provinces	2 742	2 624
Canadian Forestry Service	2 810	1 255
Federal/provincial agreements	–	722
Forestry schools[b]	381	1 594
Other faculties[b]	279	1 597
	6 212	7 792
GRAND TOTAL	**6 532**	**16 264**

[a]The 1979/80 data were recorded in less detail than those of 1985/86 and virtually all expenditures on environmental research were included under the heading of Ecology.
[b]Average university expenditures from 1976 to 1978.

Appendix 3

Table 2. Expenditures on Forest Production Research

Agency	Expenditures $(000) 1979/80[a]	1985/86
Tree and Seed Improvement		
Provinces	3 244[a]	8 015[a]
Provincial research institutes	..	916
Canadian Forestry Service	2 520	3 540
Other federal agencies	250	1 539
Federal/provincial agreement	..	571
Forestry schools	..	1 975
Other faculties	..	539
Industry	..	259[b]
	6 014	17 354
Reforestation		
Provinces	667	5 906
Provincial research institutes	..	227
Canadian Forestry Service	1 700	3 902
Other federal agencies	..	291
Federal/provincial agreements	–	1 028
Forestry schools	..	415
Other faculties	..	136
Industry	..	264
	3 367	12 169
Tree and Stand Growth		
Provinces	2 011	4 208
Provincial research institutes	..	71
Canadian Forestry Service	4 580	2 572
Other federal agencies	900	1 900
Federal/provincial agreements	..	1 873
Forestry schools	598	1 195
Other faculties	195	274
Industry	1 330	322[b]
	9 614	12 415

Table 2. Expenditures on Forest Production Research (Cont'd)

Agency	Expenditures $(000) 1979/80[a]	1985/86
Management Systems		
Provinces	236	495
Canadian Forestry Service	..	2 008
Federal/provincial agreements	–	290
Forestry schools	..	240
Other faculties	..	30
	236	3 063
Unclassified Forestry Spending		
Provinces	021	–
Provincial research institutes	1 057	–
Industry	–	3 478
	2 078	3 478
GRAND TOTAL	**21 309**	**48 476**

[a]Quebec's expenditures have been divided equally between tree improvement, reforestation and tree and stand growth.
[b]Only one company gave a detailed breakdown of its research spending on forestry in 1985/86 and the rest of industry's spending appears under unclassified.

Appendix 3

Table 3. Expenditures on Forest Protection Research

Agency	Expenditures $(000) 1979/80[a]	1985/86
Fire Research		
Provinces	11	316
Canadian Forestry Service	1 910	2 523
Other federal agencies	130	12
Federal/provincial agreements	–	660
Forestry schools	..	544
Other faculties	..	172
	2 051	4 227
Pest Biology		
Provinces	568	1 840
Provincial research institutes	–	76
Canadian Forestry Service	8 760[a]	6 546
Other federal agencies	650	1 570
Federal/provincial agreements	–	182
Forestry schools	..	571
Other faculties	..	834
	9 978	11 619
Pesticides and Herbicides		
Provinces	227	421
Provincial research institutes	73	..
Canadian Forestry Service	..	2 457
Other federal agencies	..	72
Federal/provincial agreements	–	436
Forestry schools	..	169
Other faculties	..	724
Industry	..	43
	300	4 322
Biological and Integrated Pest Management		
Provinces	..	134
Provincial research institutes	..	49
Canadian Forestry Service	..	4 233
Other federal agencies	..	200
Federal/provincial agreements	–	160
Other faculties	..	168
	..	4 944

Table 3. Expenditures on Forest Protection Research (Cont'd)

Agency	Expenditures $(000) 1979/80[a]	1985/86
Unclassified Research		
Forestry school	253	–
Other faculties	406	–
	659	–
GRAND TOTAL	**12 988**	**25 112**

[a]Includes CFS research on chemical and biological control.

Appendix 3

Table 4. Research Expenditures on Non-consumptive Uses of the Forest

Agency	Expenditures $(000) 1979/80[a]	1985/86
Wildlife and Fisheries		
Provinces	..	1 759
Provincial research institutes	..	76
Canadian Forestry Service	–	–
Other federal agencies	..	76
Forestry schools	..	692
Other faculties	..	102
Industry	..	53
		2 758
Rangeland Management		
Provinces	..	178
Forestry schools		87
		265
Recreation		
Forestry schools	..	24
Other	..	11
		35
Urban Forestry		
Forestry schools	..	68
Unclassified		
Forestry schools	191	–
Other faculties	222	–
	413	–
GRAND TOTAL	**413**	**3 126**

Appendix 3

Table 5. Expenditures on Forest Utilization Research

Agency	Expenditures $(000) 1979/80[a]	1985/86
Energy from the Forest (ENFOR)		
Provinces	..	91
Provincial research institutes	254	..
Canadian Forestry Service	418	331[a]
CFS (ENFOR)	4 220[b]	–[c]
Other federal agencies	500	2 277
Federal/provincial agreements	–	308
Forestry schools	..	198
Other faculties	..	874
	5 392	4 079
Solid Wood Products		
Provinces	..	324
Provincial research institutes	2 778	1 189
Canadian Forestry Service	–	622[d]
Other federal agencies	..	71
Federal/provincial agreements	–	1 929
Forestry schools	..	453
Other faculties	..	269
Forintek	8 800	11 416
Industry	4 050	4 656
Industry suppliers	3 350	5 695[e]
COFI	..	400
	18 978	27 024
Pulp and Paper		
Provinces	–	320
Provincial research institutes	530	1 381
Federal agencies (NRC)	..	1 065
Forestry schools	..	560
Other faculties	..	1 571
PAPRICAN	9 950	19 609
Industry	17 000	27 134
Industry supplies	5 625	9 562[e]
	33 105	61 202

Table 5. Expenditures on Forest Utilization Research (Cont'd)

Agency	Expenditures $(000) 1979/80[a]	1985/86
Forest Engineering		
Provinces	566	91
Provincial research institutes	775	487
Canadian Forestry Service	–	52
Other federal agencies	..	29
Federal/provicial agreements	–	10
Forestry schools	..	412
Other faculties	49	228
FERIC	2 000	4 103
Industry	660	323
Industry suppliers	2 825	4 802[e]
	6 875	10 537
Miscellaneous[f]		
Provinces	102	–
Provincial research institutes	204	–
Federal agencies	–	700
Forestry schools	894	–
Other faculties	126	–
Industry	..	6 185
	1 326	6 885
GRAND TOTAL	**65 626**	**109 729**

[a] In-house research plus overhead and management costs.
[b] Contract research not shown elsewhere.
[c] All contract research, shown under other agencies.
[d] Administration and overhead for solid wood products and codes and standards research, plus contract research not shown elsewhere.
[e] 1979/80 expenditures converted to 1985 dollars.
[f] Much of this data was classified only under the heading of forest products.

Appendix 3

Table 6. Expenditures on Forestry Services

Agency	Expenditures $(000) 1979/80[a]	1985/86
Forest Insects & Disease Survey		
Provinces	..	62
Canadian Forestry Service	3 640	5 493
Federal/provincial agreements	–	5
	3 640	5 560
Forest Resource Data		
Provinces	298	526
Canadian Forestry Service	1 130	1 407
Other federal agencies	120	–
Federal/provincial agreements	–	421
Forestry schools	..	57
Other faculties	29	–
	1 577	2 411
Technology Transfer		
Provinces	138	4 027
Canadian Forestry Service	1 042[a]	1 993
Federal/provincial agreements	–	431
Forestry schools	..	50
Other faculties	..	118
	1 180	6 619
Special Grants & Contracts		
Provinces	–	142
Federal/provincial agreements	–	90
		232
GRAND TOTAL	**6 397**	**15 047**

[a]Work on DND Lands.